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AIR FORCE HUMAN RESOURCES

MAINTENANCE TRAINING SIMULATOR DESIGN AND ACQUISITION

By

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This report has been reviewed by the Office of Public Affairs (PA) and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.

This technical report has been reviewed and is approved for publication.

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The project explored the problems of maintenance training simulation design and acquisition. The report (a) describes the research activities that were performed; (b) describes the products and reports produced, as well as the reactions of the intended audiences to these products; and (c) presents a list of problem areas, recommendations, and areas for future research. The report describes the procedures developed for designing and documenting maintenance trainers; i.e., the procedures for determining when to use a simulator, the procedures for determining the degree of fidelity of the trainer components, and the procedures for selecting and defining the instructional features of the maintenance trainer. In addition, the report describes the project-generated *ISD (Instructional System Development) Derived Training Equipment Design* model over

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specification and the *Prime Development Specification for Maintenance Training Simulators*. Both are model or generic specifications. The ISD-derived model specification is used to communicate to the System Program Office (SPO) the results of the ISD analysis (with respect to training equipment requirements). The Prime Development Model Specification is used by the SPO to construct a procurement specification, which contains both training-oriented and engineering requirements. The report also discusses *nine problem areas*: e.g., the increasing emphasis for an accelerated acquisition schedule, the lack of continual communications between ISD analysts and SPO personnel, the reassignment of ISD analysts and the lack of documentation of corporate knowledge. For each problem, recommendations/alternative-solutions are offered.

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SECTION I

INTRODUCTION

This document is the final report of a project conducted under Contract No. F33615-78-C-0019 with the Technical Training Division, Air Force Human Resources Laboratory (AFSC), Lowry Air Force Base, Colorado. This report has several purposes:

1. To describe the research activities that were conducted.

2. To describe the major products that were generated and report the reaction to those products by their respective audiences.

3. To present a list of problem areas, recommendations, and areas for future research.

The General Problem

As weapons systems become more sophisticated so must the required maintenance capabilities of the Air Force. However, while maintenance capabilities must be increased, training budgets are shrinking. These factors, and the large attrition rate of Air Force maintenance personnel, make an increase in the cost-effectiveness of maintenance training essential. The use of simulators is assuming growing importance as one thrust toward improvement. Simulation, long an established training technique for system operators, (e.g., pilot training) has a number of potential benefits when applied to teaching maintenance. These benefits include reduced cost, increased training equipment reliability and availability, student and instructor safety when practicing hazardous maintenance activities, increased hands-on practice, malfunction insertion and creation capabilities, and built-in instructional features such as automatic student monitoring. However, the realization of these advantages has, to date, been less than optimum. The reasons for not achieving the desired and predicted advantages of maintenance simulators are varied and complex. The current project was designed to examine two areas contributing to the problem. The first area concerned, the process used to design maintenance training equipment,

commonly referred to as the Instructional Systems Development (ISD) process. The second area concerned the acquisition process; i.e., the procedures followed by the System Program Office (SPO) to acquire maintenance trainers.

Typically, maintenance training is designed by an ISD analyst. During the ISD analysis, the need for a maintenance trainer is investigated. If a trainer is indicated, the requirements of the trainer are established by the analysts. These requirements are then submitted to the SPO. At the SPO, the training requirements are reviewed, validated and engineering requirements are added. The SPO then distributes the procurement specification to contractors and vendors for bids. Upon award of the contract, the SPO a sumes responsibility for managing the acquisition process, including the quality assurance testing of the training device. The current project was designed to analyze these procedures and generate materials for improving the design and acquisition processes, so that the advantages of maintenance trainers could be better realized.

Project Objectives

Given the general problem (advantages of simulation not being completely realized), the project was designed to meet four general objectives:

1. To document existing ISD procedures for designing maintenance training equipment, specifically maintenance trainers.

2. To document existing SPO acquisition procedures.

3. To expand upon the existing ISD procedures for making training equipment design decisions for establishing training equipment design requirements and to provide a mechanism for communicating the ISD-derived training equipment design to SPO personnel.

4. To clarify existing SPO acquisition procedures and/or develop new procedures, processes, and/or materials in order to assist the SPO Acquisition Manager to more easily specify maintenance training equipment requirements (both training and engineering requirements) and to better manage the acquisition process.

A review of the four objectives reveals that two of the objectives concern the ISD-side of the acquisition process (objectives 1 and 3), while the remaining two objectives concern the activities of the SPO Acquisition Manager. The first two objectives were included to assure that any or new procedures would be compatible with the existing procedures.

Background Information

The project and its four objectives were not conceived in a vacuum. There was some speculation concerning why simulation had not been more successfully employed in maintenance training. One of these concerned the amount and type of information made available to the contractor or vendor while he was designing and fabricating the trainer. The problem is best explained by Pohlmann, Isley, and Caro (1979).

> "Simulator specification and other design and procurement documents seldom address operational training concepts or instructor roles. By contrast, information about the aircraft to be simulated and its operational environment is addressed in these documents and serves as a guide for simulator design. Usually training objectives documents provide further design guidance to assure that the required skills and knowledges can be developed in the planned simulator. But, there is no guidance to aid the designer in assuring that the operation necessary for efficient training in the planned simulator can be conducted. While . . . features may be specified in the design documents, the manner in which they are expected to be employed by the users of the simulator simply is not made known to the device designers."

Thus, it was speculated that part of the problem was in the way procurement documents were written, i.e., there appeared to be an absence of a convenient mechanism for providing instructional use information to contractors or vendors. This situation was blamed for receiving simulators which were often considered inefficient, had features which were time consuming and awkward for the instructor to use, and generally contained features which were inappropriate to the training being conducted on the device. Thus, one of the problems to be corrected concerned generating and communicating information to the vendor concerning how the intended trainer was to be used by the instructor in the training situation.

A second problem concerned the guidance available to the ISD analyst in making critical training equipment design decisions. The primary document used by the ISD analysts is AFP 50-58, Handbook for Designers of Instructional Systems. This document provides little guidance to the ISD analyst in making such critical design decisions as when to use a simulator, what degree of fidelity needs to be used to represent the component being simulated, and what instructional features the intended device should have. That is, AFP 50-58 is of little help to the ISD analyst when designing maintenance training equipment and establishing maintenance training equipment requirements. Since the development of AFP 50-58, researchers have been making some advances in identifying the specific issues to consider when making such critical training equipment design decisions. Thus, for this effort, one of the areas that needed to be investigated concerned the development of more effective design tools.

A secondary impact of a lack of decision-making tools upon the trainer design process, is that it becomes difficult to trace the origin of any design feature. For example, if a trainer is fabricated and it is later discovered to have ineffective or inefficient features, then without decision-making tools which document how such decisions were made, it would be difficult to trace where in the process the feature was determined. That is, sound decision-making tools which provide decision documentation not only facilitate the design of the maintenance trainers, but also make it easy to trace the design decision made to determine why such design features were originally identified as being useful. Thus, it was believed at the onset of the project that ISD analysts could benefit from the development of procedures and tools to design maintenance trainers and document trainer requirements.

These concerns made it clear that the project, under the four specified objectives had to:

1. Develop a model or generic specification for maintenance training equipment, which included a reasonable amount of information concerning how the intended trainer and its features were to be used by the instructor to bring about the desired training.

2. Identify existing or develop new technologies which would facilitate the design of maintenance trainers and permit design decisions to be traced from the original decision-making logic to the completed trainer.

At the beginning of the project there was no firm commitment concerning the content and format of the model or generic specifications.

There was, however, a notion that perhaps two model or generic specifications would be needed. One specification which would be prepared by the ISD analyst to communicate the results of the ISD analysis (e.g., to specify training requirements and contain information concerning how the intended trainer would be used by the instructor) and another which would be prepared by the SPO. The SPO-prepared specification was envisioned as a translation of the ISD-derived specification into a legal document binding the contractor or vendor. In addition, it was anticipated that the SPO generic specification would contain not only engineering requirements but also training requirements. This notion about the need for two generic specifications proved to be warranted as the project continued and, in fact, two model or generic specifications were constructed.

Although the specific content and format of the model specifications was unclear at the project's inception, there was some general notion concerning the process or procedure for designing maintenance trainers. This notion consisted of a theoretical structure for determining training equipment characteristics. Because this notion or theoretical structure influenced the initial direction of the project it is discussed in this section of the report.

Taxonomic Approach

At first the project staff thought that a theoretical framework for designing maintenance trainers was possible; i.e., there had been some research reported in the literature which suggested a promising approach. For completeness in documenting the project, it seems reasonable to explain to the readers of this report, the conceptual framework the project initially had in mind for designing maintenance trainers. However, it should be made clear that this initial conceptual framework was not entirely retained in the products produced by the project. As the project continued and the state-of-the-art was documented and more clearly understood, it became more apparent that the initial conceptual framework employing taxonomies was not entirely workable.

This initial framework for designing maintenance trainers was theoretically simple and straightforward. It consisted of a prescriptive model for deriving training equipment characteristics and requirements from task description and analysis data. All writers in the literature seemed to agree that to arrive at a set of training requirements (as well as training equipment characteristics) task descriptions had to be carefully analyzed. In addition, all authors seemed to agree that the first step in the analysis process was to classify or categorize the behaviors involved in the performance of the task. This

classification step was thought to be the critical step in the process because there was a strong belief that each class of behavior was invariant with respect to the principles of learning, training techniques, and the like. That is, it was believed that if the type of behavior was known, the procedures (techniques, methods, and materials) of how that behavior was acquired by the trainee were also known. It was believed by the project staff that if a task behavior could be correctly classified then its classification would lead to a determination of when a simulator would be needed, what instructional features would be required, and what level of physical and psychological fidelity the device would have to have to be effective for training. This belief was reinforced by the available literature. The project staff was aware that others had developed similar taxonomic approaches to select media and teaching methods. Thus, the project staff felt that not only could media and method be determined from the behavioral class but so too could the characteristics of simulators.

This initial framework implied a simple procedure for the design of maintenance trainers. All the ISD analyst would have to do is:

1. Identify tasks.

2. Classify the behavior involved in the task performance.

3. Go to a learning or design guide for that class of behavior and

    a. Determine if practice is needed on a simulator.

    b. Determine the level of fidelity required for the behavior to be acquired.

    c. Determine the instructional features that would be required.

That is, each learning or design guide would provide information concerning whether practice is required on a simulator and also would list all the features the practice device needed to have to be an effective training device. As the project continued a review of literature was conducted to determine the feasibility of developing and applying this simple theoretical framework. The results of the review of literature are presented in a project working paper, <u>Behavior Taxonomies and Training Equipment Design: A Review of Literature and General Model</u> (April 1979). This review indicated that there would be some problems in applying the framework:

1. Almost all the existing approaches which related taxonomic elements (behavior class) to learning principles, failed to support the associations with empirical evidence. In addition, few of the approaches reviewed showed any useable relationship between the taxonomic elements and functional equipment characteristics; i.e., most of the approaches offered a relationship between the behavioral class and learning principles and/or equipment classes (e.g., a familiarization trainer), but failed to take the process to the next desired step and show a relationship between the principles of learning and specific equipment characteristics. The impression received by the project staff was that the state-of-the-art was just not quite there yet and empirical evidence could not be marshalled to show sound relationships between the principles of learning and such equipment characteristics as the fidelity level of stimulus components. However, it was clear that with some effort the principles of learning could be used by the project staff to develop analytical procedures for selecting some instructional features.

2. Most of the taxonomic structures reviewed were appropriate for operator training (e.g., pilot training) but were not appropriate to describe typical maintenance behaviors on sophisticated weapons systems. For example, current weapons systems use computers to aid maintenance task performance. None of the approaches reviewed in the literature dealt with computer-oriented types of behaviors typically encountered by modern maintenance personnel.

3. Although highly publicized as a reasonable approach, the mechanisms available for classifying a task behavior into a single taxonomic element were found to be less than systematic and reliable. The most promising approach utilized a standardized verb list; that is, each verb that could be used to describe a task behavior is assigned to only one taxonomic element (behavioral class). This approach requires constructing a verb list along with precise definitions of each verb on the list and predetermining the class of behavior the verb belongs to. Although verb lists were available, a review of those lists revealed that most of the verbs were suitable for describing operator behavior but that few of the verbs were appropriate for describing typical maintenance tasks; noticeably absent were those for describing troubleshooting behavior and the use of computers in performing maintenance tasks.

4. None of the procedures or approaches reviewed offered a reasonable way to determine if a task behavior needed to be practiced on some sort of trainer. All the procedures that showed a relationship between a taxonomy or behavior classification scheme and training equipment types assumed that the user started out with only those tasks where training equipment of some sort was needed. As such, these procedures would not provide guidance in determining whether or not training equipment was required.

These problems as well as others dampened the project's enthusiasm for applying the original taxonomic framework. It became quite obvious in the progress of the project that such a simple theoretical framework would not work until educational and psychological researcher established more concrete associations between behavioral classes (taxonomies) and learning techniques. It was also clear that not enough was known about particular learning strategies or techniques and their association to equipment characteristics, such as levels of fidelity. Both of these drawbacks required more resources to overcome than what were available to the project. Indeed the research needed to overcome these obstacles would only come as the state-of-the-art advanced and such advances would only come slowly. In fact, the project itself generated some products which should be considered advancements in the state-of-the-art and go a long way in eventually developing the theoretical framework described above.

Given this situation the project was resigned to use the information that was available from the literature (in modified forms) to generate training equipment design decision logic which could be immediately employed by ISD analysts. The materials developed by the project make use of a taxonomic structure, but not to the extent originally anticipated. For example, a taxonomic structure is used to assist the ISD analysts in determining some instructional features. In addition, some of the materials and job aids which were developed have their foundations in a taxonomy of behaviors (e.g., the procedures used to identify tasks to be acquired and/or practiced on simulators were directly derived from a taxonomic structure developed by the project).

Overview of Approach

Given the general problem and the specified project objectives, an approach was designed. A summary of the approach appears in Figure 1. A quick glance at Figure 1 reveals that the project activities were divided into two major categories; those activities which impacted upon: (1) the ISD side, and (2) the SPO side of the acquisition process. For

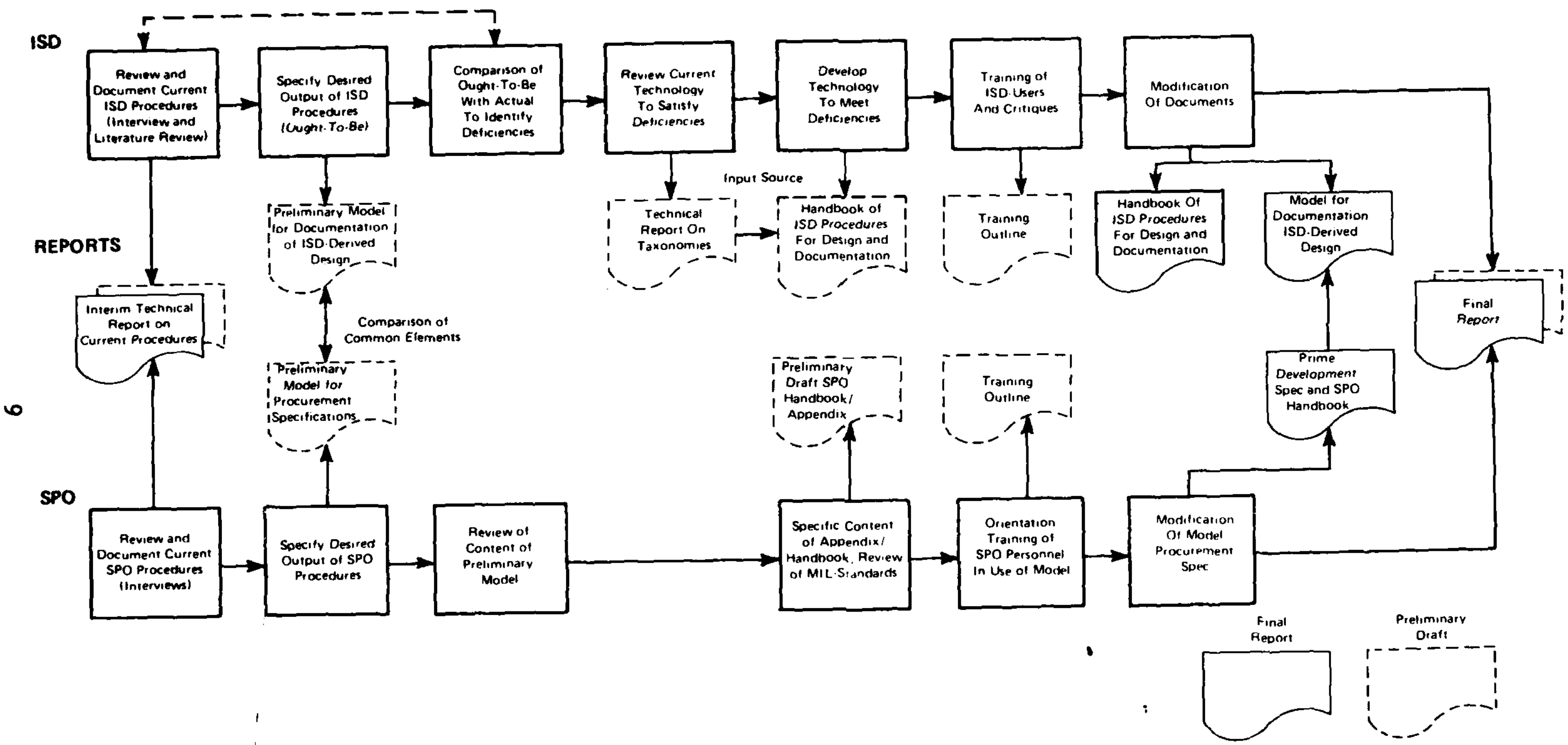

Figure 1. Summary of Project Approach

clarity and convenience, Figure 1 also illustrates the reports (products) generated by each of the activities. The arrows connecting the ISD side and SPO side (via the reports) illustrates the interface between the SPO and ISD project activities; e.g., an interface arrow appears between the ISD-derived model specification and the SPO generic specification to show that the two specifications were designed to compliment each other.

For summary purposes each major project activity is discussed below.

ISD Project Activities

The ISD project activities consisted of the following:

1. Documentation of Current ISD Process. Through interviews with ISD teams within the Air Force it was determined that a formal ISD analysis was generally accomplished only for new weapons systems. Further, the 3306th Test and Evaluation Squadron (Edwards Air Force Base, California) was identified as a successful organization in applying ISD procedures for determining maintenance training equipment characteristics. They developed an adaptation of the ISD process described in AFP 50-58. Their ISD process was taken by the project as the baseline Air Force ISD process; i.e., it served as the process which would be supplemented by any ISD techniques developed by the project. It should be noted that the 3306th was eager to see improvements in their own process.

2. Specification of Desired ISD Outputs. To determine where areas of improvement in the current ISD process were needed, a statement of the desired ISD outputs was formulated. This statment was eventually translated into the model specification that is prepared by the ISD analysts. The statement of the desired ISD outputs were formulated by interviews with ISD analysts, SPO engineers, as well as by the experience of the project staff.

3. Comparison of Desired ISD Outputs to Actual Outputs. A comparison between the desired ISD output and the actual output of the then current ISD process highlighted where areas of improvement were necessary and could be realized.

4. Review of Current Training Technology. Given where areas of improvement were needed to generate the desired ISD outputs, a review of the literature was conducted to identify

if any existing technologies could be used. The review concentrated on the taxonomic approach discussed above.

5. Develop Training Technology to Generate Desired ISD Outputs. The review of literature as discussed above, indicated that new approaches had to be developed. Thus, the project developed procedures and job aids to assist the ISD analyst in making critical training equipment design decisions. Efforts were concentrated on developing procedures for:

   a. Determining when practice was required on a trainer of some sort.

   b. Determining the degree of fidelity of the components to be represented on the maintenance trainer.

   c. Determining the nature and the type of instructional features required on the maintenance trainer.

   d. Documenting the results of the ISD analysis and completing or preparing the ISD-derived model specification.

   These procedures were included in a Handbook developed specifically for the ISD analysts. The Handbook should be viewed as a supplement to the ISD procedures offered by the 3306th Test and Evaluation Squadron.

6. Conduct ISD-Team Training. Given the ISD Handbook and the procedure for communicating the ISD-Derived Training Equipment Design, the next step was to train ISD analysts. The training served two purposes; first, it exposed the 3306th Test and Evaluation Squadron to the procedures developed by the project and, second, it provided an opportunity for the 3306th to offer suggestions for improving the products generated by the project.

7. Modification of ISD Materials and Products. After the training, the developed materials were modified and written in final form.

It should be noted that the ISD project activities were conducted simultaneously with the SPO project activities. Interface between the two areas occurred in activities 1, 2, 5 and 7 listed above. Of particular concern was the coordination between the ISD-Derived Training Equipment Design (model ISD-derived specification) and the model specification prepared by the SPO (Prime Development Specification for

Maintenance Training Simulator). This type of coordination was required to assure that the two model specifications could be easily integrated and to guarantee that they complimented each other.

SPO Project Activities

The SPO project activities consisted of the following:

1. Documentation of Current SPO Procedures. Through interviews with SPO personnel (including such support personnel as the engineering staff), the SPO procedures for acquiring maintenance trainers was documented. During the interviews, it became clear that the project could make its best impact on the SPO contribution to the acquisition process by developing a prime development model specification for maintenance trainers. That is, the SPO group strongly felt that help was needed in preparing the procurement specification to assure that both training and engineering requirements were adequately described to the vendor or contractor.

2. Develop Model SPO Specification. SPO procedures primarily consist of receiving the results of the ISD analysis and preparing a specification which is eventually distributed to contractors or vendors. After the award of the training equipment contract, the SPO also has the responsibility to manage the acquisition process (including testing of the delivered device). The specification was typically prepared by using the results of the ISD analysis (e.g., training objectives, training applications, determined level of fidelity, type and kind of instructional features, etc.) and by adding engineering requirements (e.g., requirements dealing with the maintainability and reliability of the maintenance trainer). Preparation of the trainer specification requires the engineer to review appropriate Military Standards and Specifications. To assist the engineer in the preparation of the specification, a model specification was constructed by the project. This model contains both training-oriented requirements and engineering requirements.

3. Review of Model SPO Specification. After a preliminary draft of the model SPO specification was prepared, it was reviewed by SPO engineers. Of primary concern during the review was the completeness of the model SPO specification; i.e., did it contain all required content areas and requirements. Since it was to be a model specification, it

had to be applicable to all types of situations and maintenance trainers and, thus, had to contain all possible requirements.

4. Specify Content of SPO Handbook. After the preparation of the preliminary draft of the model SPO specification it was decided that to assist the engineer in using the model SPO specification, a Handbook was needed. A Handbook was developed by the project and serves as a guide to the engineer in determining what paragraphs or subparagraphs of the model specification are appropriate and need to be applied in any given situation. In addition, the Handbook provides guidance in determining how to use:

    a. The available Military Standards and Specifications which specified parameter values for the engineering requirements.

    b. The ISD-Derived Training Equipment Design model specification (this document served as a primary source in the preparation of the model SPO specification).

    In addition, the Handbook also contains a section for each requirement called Lessons Learned. This section of the Handbook specifies what had been learned from previous acquisitions of trainers; e.g.,

    a. It contains suggestions for phrasing requirements which had worked in the past as well as suggestions for avoiding phrases which had not worked in the past.

    b. It contains a summary of corporate history or experience in stating content requirements in certain ways; i.e., it discusses how potential contractors and vendors might interpret certain phrases or requirements.

5. Conduct SPO Orientation Training. After the model SPO specification was prepared, as well as its accompanying Handbook, the next step was to provide SPO personnel with orientation training. The training was designed to serve two purposes. First, it provided the SPO engineers an opportunity to see both the model SPO specification and the accompanying Handbook. Second, it provided the project staff with an opportunity to receive comments concerning how these two documents could be improved.

6. Modification of SPO Materials. After the orientation, training modifications were made in the materials and they were submitted in final form.

A review of the project activities reveals a common strategy for attacking both the ISD and SPO sides of the maintenance training equipment acquisition process. Both sides of the process started with the complete documentation of the respective existing procedures. This was followed by specifying the ought-to-be or desired outputs of both sides. The next step in both sides of the project activities consisted of a comparative analysis; i.e, comparing the desired outputs with the current or existing outputs of both the ISD design process and the SPO acquisition procedure. The comparative analysis revealed where areas of improvements could be realized. After identification of the areas of improvement, materials, job aids, and procedures were developed. Following the development of the materials, project-developed training occurred. This training concentrated on how the project-developed materials were to be used. After the training sessions, the products were modified and submitted.

Overview of Project Products

The project activities briefly described above generated several products (reports). The primary or major products produced were:

1. Maintenance Training Simulator Design and Acquisition: Summary of Current Procedures (AFHRL-TR-79-23, November 1979). This report summarized both the 3306th ISD process and the SPO acquisition procedures. In addition, the report presented a listing of the major problem areas associated with both processes--the training equipment design process and the acquisition process. This report became the starting point for the rest of the the products generated by the project; i.e., it represented the ISD and SPO process from which improvements could be realized.

2. Maintenance Training Simulator Design and Acquisition: Handbook of ISD Procedures for Design and Documentation (in Air Force publication cycle at the time of this writing). This Handbook presents job aids for assisting ISD analysts in making critical training equipment design decisions. Although procedures were developed for making many design decisions, this Handbook concentrates on three critical decisions:

a. A method for determining which skills and knowledge had to be acquired using a trainer of some sort; i.e., which required hands-on experience/practice for the students to acquire them.

b. A procedure for making fidelity decisions; i.e., for determining the level of fidelity that components on the trainer should be represented by.

c. A procedure for selecting the essential instructional features. Typically, these instructional features involved computer-driven or controlled features, such as, automatic scoring, provisions for the presentation of augmented feedback messages, provisions for updating parameter values, etc.

All decision-making procedures are offered in flow chart formats. It should be pointed out that the job aids are designed to provide guidance on the application of learning principles in making training and training device design decisions, rather than just being principle oriented.

It should also be mentioned that the ISD Handbook contains procedures for considering how the training device would be used by instructors and be incorporated into the total training program.

All the job aids and design steps offered in the Handbook are designed to provide or generate the information needed to complete the <u>ISD-Derived Training Equipment Design</u> (model specification). That is, every procedure in the ISD Handbook can be associated with a paragraph or subparagraph of the ISD model specification. The ISD Handbook not only offers guidance in designing maintenance trainers, but also provides a method for documenting those design decisions for both traceability and communication purposes.

It should be emphasized that the Handbook is designed to be a supplement to the 3306th <u>Procedural Handbook</u>. It is not designed as a substitute for the 3306th <u>Procedural Handbook</u>. It should be recalled that our mission was to build upon existing procedures; i.e., to fill the gaps that existed in the current ISD process.

It should also be realized that the Handbook is designed to contain procedures for documenting important design decisions. That is, the Handbook is purposely designed to

assure that the design decisions made can be traced. This feature guaranteed that down the road improvements could be made in the decision logic procedures.

3. Maintenance Training Simulator Design and Acquistion: ISD-Derived Training Equipment Design (currently in the Air Force publication cycle). This document contains paragraphs and subparagraphs to be completed by the ISD analysts during and after the ISD analysis; i.e., it contains blanks which must be completed by the ISD analysts. The blanks make it possible to tailor the specification to a specific application; i.e., the model ISD-derived specification was constructed to be applicable to all types of maintenance trainers. The document is designed to be the vehicle by which the results of the ISD analysis are communicated to SPO personnel. This model ISD-specification contains information categories related only to training issues; for example, specification of:

   a. Training objectives (tasks to be acquired, malfunction isolation procedures to be practiced).

   b. Training applications (how the trainer is to be used by the instructors).

   c. Fidelity levels (the physical and functional characteristics of the components or parts to be represented on the trainer).

   d. Instructional features (e.g., the description of the automatic scoring and malfunction insertion features).

   Since the ISD-derived specification is a generic specification, accompanying the model ISD-derived specification is a set of instructions for applying the model in specific situations and for using the information generated by the procedures specified in the ISD Handbook. That is, the instructions accompanying the model ISD-derived specification discuss how the outputs of the procedures specified in the ISD Handbook are used in the preparation of the ISD-Derived Training Equipment Design. For example, the procedures for determining the level of fidelity of the components to be represented on the trainer result in a description of the component (its size, shape, color, texture, etc.). The instructions accompanying the model

ISD-derived specification explain how this information is to be recorded in the model ISD-derived specification, so that such decisions can be traced as well as communicated to the SPO personnel. The instructions also provide some lessons learned on ways of stating the trainer requirements. These were lessons learned from previous ISD efforts as well as past trainer specifications. In addition, the instructions provide guidance on how the blanks can be completed.

It should also be mentioned that the model ISD-derived specfication was designed to be completed during and after the ISD analysis. That is, the ISD-derived specification was purposefully designed to provide a vehicle for communicating the results of the ISD analysis, as they are known, to the SPO personnel. In this way, the precise intention of the ISD analyst can be discussed and clarified for the SPO personnel.

4. Maintenance Training Simulator Design and Acquisition: Prime Development Specification for Maintenance Training Simulators (in Air Force publication cycle at this writing). This document contains the generic SPO specification and the accompanying SPO Handbook/Appendix. The SPO specification contains both engineering requirements and training requirements. The training requirements are derived from the ISD-derived model specification while the engineering requirements are derived from existing Military Standards and Specifications. The SPO Handbook was attached to the model SPO specification as an appendix, thus, the SPO Handbook is often referred to in this report as a SPO Handbook/Appendix.

Both the ISD-Derived Training Equipment Design and the Prime Development Specification for Maintenance Training Simulators have an unusual format. They are generic specifications and, thus, can be tailored to the specification of requirements for any type of maintenance trainer used in any type of situation (e.g., resident training or field training). Because they are generic, they contain all possible paragraphs and subparagraphs which might be included in a maintenance trainer specification. In addition, they contain blanks (the blanks allow the preparer to tailor the paragraphs or subparagraphs to his needs). The blanks usually appear where the specific requirements are to specified. Because the specifications are generic, instructions are needed to accompany the specification. These instructions are:

a. Help the preparer determine what paragraphs and subparagraphs are appropriate in his situation.

b. Assist the preparer in completing the blanks (stating the particular requirement or parameter that establishes the requirement). In addition, sources where the parameter is set by Military Standards are stated, as well as where in the ISD Handbook procedures are established for deriving the requirement. In the case of the SPO specification, directions for using the ISD-derived specification are offered.

c. Provide lessons learned from previous equipment acquisitions. These lessons learned contain:

   - Cautions in the way the requirement is stated.

   - A description of what was done in the past and what can be expected from vendors and contractors.

All the products were very well received by their intended audiences. The reaction that the intended audiences had to the developed projects is reported in Section III of this report. For completeness, those reactions are summarized here:

1. The ISD analysts felt that the design procedures for making critical design decisions, for tracing decisions, and for communicating the results of the ISD analysis to SPO personnel involved a lot of paperwork.

2. Both the ISD analysts and the SPO engineers felt that the concept of having two specifications would work, and that the ISD-derived specification would guarantee that training-related issues would not be misrepresented in the final procurement specification.

3. Both the ISD-derived specification and the model SPO specification attended to:

   a. The problem of taking advantage of corporate history through the lessons learned section of each specification.

   b. The problem of specifying how the trainer will be used.

For summary purposes it should be pointed out that two products were developed for the ISD team (a procedure Handbook concerning design decision logic and a model ISD specification for communicating the results of the ISD analysis. In addition, one product was developed for the SPO side of the acquisition process (a model SPO specification and an accompanying Handbook/Appendix, which provides assistance in completing the model SPO specification. It should also be mentioned that these products were designed for both intermediate and organization level maintenance trainers.

In addition to the major products listed above, the project generated other reports:

1. Behavior Taxonomies and Training Equipment Design: A Literature Review and General Model (April 1979). This report is a project working paper and presents a review of the models available to design maintenance trainers.

2. Maintenance Training Simulators Design and Acquisition: ISD Team Training Course Outline (December 1979). This report presents the objectives and content of the ISD team project training.

3. Maintenance Training Simulator Design and Acquisition: SPO Orientation Training Outline (February 1980). This report presents the objectives and content of the SPO orientation project training.

Summary of Problem Areas

During the project, several problem areas concerning the design and acquisition phases of maintenance trainers emerged. These problem areas are briefly summarized here and discussed in detail in Section IV of this report:

1. ISD Analysis Compression. There has been considerable pressure exerted to accelerate the acquisition cycle. Such an accelerated schedule has resulted in a decrease in the time available to conduct the ISD analysis. Several solutions to this problem exist:

    a. Increase manpower available to conduct the ISD analysis.

b. Decrease or compression of the ISD analysis itself (reduce the procedure involved). In fact, it has been suggested that the "computerization" of the procedures specified in the project-developed Handbook would help. The procedures in the Handbook are in a flow chart format and can be easily programmed for processing by a computer.

It has also been suggested that the preparation of both specifications using a word processor (or similar device) would also help to compress the time needed to perform the ISD analysis.

c. Schedule the delivery of the trainer to coincide only with the training of apprentice 3 level personnel (i.e., the trainer may not be needed during the conversion training where 7 levels are trained).

2. Increased Communications. Part of the problem associated with training equipment design, has been the lack of continual communication between ISD and SPO personnel. Several solutions to this problem have been recommended:

   a. The design and acquisition of maintenance trainers can be performed as a team effort. The team should contain ISD personnel and SPO personnel (particularly design engineers).

   b. Meetings between the groups should be periodically scheduled to increase the content and quality of the communications. The project-generated ISD specification can be used as a reference for such meetings.

3. ISD Staffing and Experience. ISD personnel are trained maintenance personnel; they receive very little formal training in instructional, educational, and psychological processes. They are typically assigned to only one project where a maintenance trainer is developed, then they are transferred, usually to a field position. During their assignment to perform an ISD analysis, they gain a tremendous amount of experience in training equipment design. It is reasonable to suggest that once this experience is gained, it should not be lost to the Air Force because of military transfers. Trained individuals should stay longer at the 3306th.

In addition to maximizing the ISD experience, ISD analysts should be required to follow the design and acquisition of a maintenance trainer all the way through to its use. That is, analysts should:

a. Perform the ISD analysis and make training equipment decisions.

b. Be involved in the procurement of that device; i.e., work closely with the contractor during the design and fabrication stages (to assure that the trainer is designed the way it was intended).

c. Participate in formative and summative evaluations of the trainer (during its fabrication and its use by the using command).

d. Use the trainer during the training program with the instructor.

After such experiences the analysts should return to the 3306th and begin another ISD project. Such an approach would result in better trainers being designed. The experiences gained by this approach might permit the ISD analyst to be involved in the different stages of two or more ISD efforts at the same time.

4. Current State-of-the-Art Exposure. ISD analysts must keep current concerning the capabilities of maintenance trainers as well as how maintenance trainers can be used. They should be in contact with vendors and contractors. In addition, they should be given the opportunity to be exposed to maintenance trainers developed by all branches of the military; e.g., they should go to Hill AFB to see the F-16 SAMTs, to Lowry to see the 6883, etc. Such an exposure would broaden the analyst's frame of reference as well as facilitate the transfer of corporate knowledge.

5. Engineering Change Proposal Analysis. One of the content areas of the model ISD specification concerns the specification of probable engineering changes in the operational equipment which will affect the maintenance trainer. Completion of this paragraph in the model specification would be facilitated by studying past engineering change proposals to determine:

a. Where changes are likely (what system, etc.).

b. The nature of these changes (location changes, functional changes, etc.).

c. How the trainer could be designed to accommodate expected changes.

6. One ISD Handbook. The project-developed ISD Handbook was designed as a supplement to the 3306th Procedural Handbook. Some of the students in the project-presented training course expressed a desire to have both documents integrated into a single Handbook.

7. Contractor-Provided Data Base. Currently there are no standards governing the content and format of the data base used by the analysts during the ISD analysis. It is perhaps possible to reduce the amount of documentation required of the project-developed ISD process by carefully designing the content and format of this contractor-provided data base.

8. Instructional Features Scenarios. Step 7 of the project-developed procedures for designing and documenting training equipment decisions concentrates on selecting instructional features which are computer-based (or computer-driven and controlled), such as automatic recording, scoring, and reporting of student responses; presentation of augmented feedback messages; the need for a storage device; the automatic highlighting of performance cues, etc. Typically, these decisions are based upon an analysis of the:

   a. Need to satisfy a particular educational principle.

   b. Time the instructor has available to perform them.

   Although the project-developed materials to select and describe instructional features, ISD analysts and SPO engineers suggested that pre-written instructional features scenarios would be helpful. The suggested scenarios would contain:

   a. A complete operational definition of the instructional feature.

   b. A description of the purpose and intent of the instructional feature.

c. A functional description of the instructional feature, step-by-step procedures for initializing the instructional feature, step-by-step procedures for making the instructional feature operational, step-by-step procedures for updating the instructional features and associated software.

d. A description of how the feature can be used with other instructional features.

e. A features diagram or functional flow chart.

Such scenaraios could be made part of the procurement specification.

In addition to computer controlled instructional features, other instructional features must also be considered, such as the noise level of the trainer, its size for conducting demonstrations, its ease of use to construct new student practice exercises, etc. Some of these types of instructional features are currently discussed in Step 5 of the project-developed ISD Handbook. It has been suggested that these types of instructional features also be expanded and incorporated in Step 5.

9. SPO Specification Enhancements. Although the project-developed model SPO specification contains both engineering and training performance requirements and was reviewed by maintenance training equipment engineers, parts of the specification require close review by specialists or experts. For example, the maintainability paragraph and its accompanying subparagraphs should be reviewed by maintainability engineers. In addition, the software/courseware paragraphs should be carefully reviewed by software engineers. Furthermore, Air Training Command (ATC) frequently stipulates some requirements which appear in the procurement specification; thus, ATC should be given the opportunity to carefully review the model SPO specification and CDRL.

Organization of Final Report

The remainder of this final report is organized in the following manner:

Section II: Approach. This section discusses in more detail the project activities as well as the contents and format of the major products. Emphasis is given to how the products are to be used.

Section III: Findings and Reactions. This section discusses how the products were received by their intended audiences.

Section IV: Problem areas and recommendations. This section discusses some of the problems encountered during the project, as well as recommendations for solving those problems.

SECTION II

APPROACH

Each of the major project activities is discussed in detail in this section of the report. The purpose of this section of the report is not only to describe the project activities, but to describe in detail the products generated by the project. The descriptions of the products emphasizes the objectives governing development of the products as well as a discussion of how the products should be used.

For ease of presentation, the project activities which impacted upon the ISD and SPO contributions to the design and acquisition of maintenance trainers are discussed separately. Although the SPO and ISD sides of the design and acquisition processes are discussed separately, it should be realized that the respective project activities were conducted concurrently. The simultaneous conduct of the ISD and SPO project activities assured that the proper interfaces between the ISD and SPO contributions to the design and acquisition processes were adequately addressed.

ISD Project Activities

Summary of Current ISD Process

The first project activity was to review and summarize the current ISD process. This occurred simultaneously with the review and summary of the current SPO acquisition procedures. If the project was to successfully build upon the existing design processes and acquisition procedures, then these processes and procedures had to be well understood and documented. The current ISD process is discussed first.

It was discovered early in the project that there was no such animal as the Air Force ISD process. Many organizations within the Air Force perform the ISD function; however, the procedures employed are different. Interviews with ISD teams throughout the Air Force revealed that there was little formal or "by-the-book" ISD analysis accomplished when analyzing training equipment requirements for existing maintenance

systems. However, the interviews revealed that formal ISD procedures were employed for determining maintenance training requirments for new weapons systems. The 3306th Test and Evaluation Squadron (T&ES), Edwards Air Force Base, California had this as its principle function. Interviews with the 3306th T&ES revealed that:

1. They had a core of highly experienced ISD analysts.

2. They had evolved over the years, an adaptation of the general ISD model to derive training requirements and training equipment characteristics for new weapons systems.

3. They had well-documented their adaptation in an organizational publication (Procedural Handbook, 3306th Test and Evaluation Squadron, June 1979).

4. They were generally successful within the Air Force in meeting Air Training Command/Air Force System Command (ATC/AFSC) requirements for new system maintenance training.

5. They recognized the need to improve upon their ISD process to design and document training and training equipment requirements.

For these reasons their ISD process was adopted by the project as the baseline Air Force ISD process.

Since their ISD process is well-documented in their own publications, it will not be presented here. In addition, an interim project technical report (Maintenance Training Simulator Design and Acquisition: Summary of Current Procedures, AFHRL-TR-79-23, November 1979) summarizes their procedure in some detail.

In addition, that technical report also presents and discusses some of the problems associated with applying the ISD process in a new weapon systems environment. Because these problems greatly influenced the direction of the project, they are briefly discussed here:

1. Because of the acquisition cycle, often operational equipment is in a state of evolution at the time of the ISD analysis. That is, frequently the ISD analysts do not have a comprehensive data base available when design and documenting training and training equipment requirements. This problem greatly influenced the project. It meant that any procedures developed by the project had to be sensitive to the fact that the contractor-furnished data base was

incomplete but expanding during the ISD process. This meant that the project had to develop procedures which would allow decisions to be made in an iterative manner, subject to change as more information in the data base became known. It also meant that the level of detail that the ISD analyst could communicate to the SPO at any given time was variable. That is, documentation procedures had to be developed which were sensitive to the sometime incomplete but expanding data base. The documentation procedure had to allow for possible changes also in the target population, as well as in the system being simulated. For example, it was not unusual for the target population to be ill-defined during the initial ISD efforts. If the target population description changed, then the documents should allow for a change in training needs.

2. The contractor-furnished data base is not standardized. Different contractors provide different types of data in different formats. This meant that the ISD procedures to be developed could not assume a standardized data base; i.e., the procedures to be developed had to allow for variability in type and kind of data that would be available to perform the ISD analysis.

3. There is no standardized mechanism available for communicating the results of the ISD analysis. What typically occurred was that the forms generated during the ISD analysis (following the 3306th procedures) were submitted to the SPO for review and validation. However, the forms themselves do not necessarily communicate the whole training story. For example, there were no forms available for communicating how the intended trainer would be used within the entire training program or for describing the characteristics of the target population, or for describing the characteristics of the instructors who would use the intended trainer. In addition, the form available for communicating the characteristics of the intended trainer was relatively open-ended. By being open-ended, the characteristics of the trainer were often not communicated unambiguously.

4. Although some materials are available for making critical training equipment design decisions, these procedures are incomplete and not systematic. For example, there were no procedures available for systematically selecting and describing the required instructional features. In addition, there were no procedures available to guide the ISD

analysts in making fidelity level decisions. Furthermore, the procedures that existed:

a. Were theory or principle oriented (little guidance was available to apply these theories or principles to specific situations).

b. Relied to a large extent on the personal preference of the ISD analyst (e.g., the need for a simulator as opposed to another media was often made based upon personal preference and not necessarily on logical considerations).

5. There is no mechanism in place to assure that the ISD analyst employs state-of-the-art technologies in designing training equipment. For example, few ISD analysts prior to assignment at the 3306th had an opportunity to participate in the design of a major trainer. Personnel responsible for designing and documenting training are not exposed to what is and what is not available. Because of this trainer characteristics were often selected based upon the operating characteristics of the equipment. There was a tendency to have the trainer precisely duplicate the actual operating equipment without concern for building in specific training capabilities. This was not necessarily considered bad, but it significantly reduced the possibility that maximum training usefulness could be derived from the designed device.

6. Because of the limited time available for determining training and trainer requirements in the acquisition cycle, ISD analysts often designed the trainer without considering the entire training program or regime. This is analogous to selecting a media, then designing the training program around the media (i.e., the trainer). The project staff strongly felt that how the trainer was to be used within the entire training program influenced the design of the trainer; i.e., its use had to be considered before the trainer was designed. It makes little sense to design the trainer then determine how the trainer could be used to achieve the training objectives. It was felt by the project staff that when the determination of how the trainer was to be used was postponed until the trainer was designed that often the trainer would be seen as ineffective, inefficient, and awkward to use.

At first glance the list of problems above appears to be a serious indictment against the application of the ISD process; however, the comments made in the interim technical report should be emphasized:

> ". . . in reviewing the specific problems with each of these areas, it is important to maintain a realistic perspective. The ISD concept is relatively new, uniquely demanding, and not widely applied. Even so, its users, particularly the 3306th T&ES, have amassed an impressive record of effective training development and implementation. This classification of existing problems needs to be taken for what it is, an attempt to identify ways in which an already successful process can be further improved in the cost-effectiveness of its products." (Maintenance Training Simulator Design and Acquisition: Summary of Current Procedures, Page 35.)

The problems areas listed above should be considered in light of the project objectives. It was our mission to identify where, in the existing ISD process, improvements could be made. It was not our mandate to be critical, but only to identify how an already successful ISD process could be improved so that the apparent advantages of simulators could be more fully realized.

It should be made clear that not all the problems discussed above were equally addressed by the project or equally solved by the project. For example, little could be done about the nature and type of contractor data bases being generated. The most that could be done in this area was to build a system which allowed this data base to be variable.

Specify Ought-To-Be ISD Outputs

Although documenting the problems associated with the ISD process went a long way in identifying what type and kind of improvements could be made, that alone would not assure the identification of all problem areas. To be more precise and accurate the project staff felt a statement of the desired (or ought-to-be) outputs of the ISD process could be drafted, then a comparison with actual outputs could be made. Such a comparison could reveal additional areas of improvement.

To specify the desired ISD outputs, the project staff asked these questions:

1. What information did the ISD analysis have to generate so that an improvement procurement specification could be constructed?

2. At what level of detail did this information have to be?

To obtain answers to these types of questions the project staff performed the following activities:

1. Reviewed existing procurement specifications to determine existing information categories which were training oriented.

2. Interviewed SPO engineers (procurement specification preparers) to determine:

   a. What training information (requirements) they felt they needed to write a "good" procurement specification?

   b. What engineering requirments were needed in the procurement specification and could such requirements be determined from the training requirements?

3. Interviewed 3306th ISD analysts to determine what information they felt needed to be communicated to the SPO personnel.

The results of the reviews and interviews revealed several things:

1. The typical *maintenance* trainer procurement specification contained a good deal of engineering information or requirements (such as maintainability and reliability requirements) which were not directly derivable from the results of the ISD analysis. This situation confirmed the project's notion that perhaps two model specifications needed to be developed - one for the ISD analysts and one for the engineering requirements. As it will be discovered later in this report two model specifications were, in fact, developed. The model SPO specification was designed to incorporate the model ISD specification as well as specify the possible engineering requirements.

2. The contention that information concerning how the intended trainer was to be used by instructors within the entire training regime was noticeably absent from most procurement specifications.

3. ISD analysts and SPO engineers strongly felt that more communication was needed between the two groups to clarify any information which was communicated. Although this result of the interviews did not help specify the desired ISD outputs, it strongly suggested that both groups were eager to increase the flow of communication and were willing to

work together to assist in formulating a statement of the desired ISD outputs.

4. There was general agreement between the ISD team and SPO engineers that currently:

   a. Not enough information was being transmitted to justify the need for a maintenance trainer (even through it was recognized by both groups that often the decision to have a maintenance trainer was made by factors and influences outside the ISD analysis structure).

   b. Not enough information was being transmitted concerning the level of fidelity the trainer should have.

   c. Not enough information was being transmitted concerning the instructional features the trainer should have.

   d. Not enough attention was being paid to several critical issues, such as the possibility of engineering changes in the operational equipment. It was felt that often the ISD team knew where possible engineering changes might occur, but that these potential changes were not systematically and routinely communicated. The SPO engineers felt that if the ISD team could communicate such possible engineering changes in the operational equipment, then things could be done in the procurement specification to assure that the vendor recognized the potential changes and, as such, designed the trainer to accommodate such changes.

   e. One area which had been seriously neglected concerned the ease with which the maintenance trainer, once procured, could be updated. This particular problem surfaced around the nature of malfunction insertion and creation capabilities. There was the feeling that vendors and contractors were designing trainers which were extremely inflexible and this problem had to be considered. For example, often the Air force was locked into the vendor to make malfunction isolation exercise updates. The ISD team felt that as the operational equipment was in operation longer, new malfunctions would surface.

If the trainer was not designed so that such new malfunctions could be easily created in the maintenance training equiment, then the training equipment lost much of its training usefulness. On the SPO side, engineers felt that it would be costly to be locked into the vendor for such changes.

f. Not enough information was being transmitted concerning software requirements for computer driven maintenance trainers. Although there was agreement concerning this information category, it was not clear who should have responsibility for specifying software requirements. The ISD team felt that they did not have enough training and experience to make such decisions or establish such requirements. Furthermore, the SPO engineers felt that they too did not have enough training nor obtained enough information from the ISD analysts to construct reasonable software requirements. In addition, however, both groups felt that the problem surrounding how software is updated needed to be addressed.

g. Not enough information was being transmitted concerning the characteristics of the intended target population, the characteristics of the instructors who would use the trainer and the environment in which the trainer would be used. However, there was agreement as to who should supply this information.

From the reviews and interviews, a statement of the desired ISD outputs was drafted. This initial statement was drafted with only two purposes in mind - to establish the information categories which needed to be communicated as well as establish, within some reasonable bounds, the detail level of that information. This preliminary statement of the desired ISD outputs offered five major information categories.

1. Training Objectives: This section of the initial draft permitted specification of:

   a. The target population who would use the intended maintenance trainer.

   b. The tasks to be practiced and/or acquired using the intended trainer.

   c. The malfunctions to be presented by the trainer for student isolation and/or correction.

d. The training objectives to be achieved or attained by the trainer.

2. Training Application: This section of the initial draft permitted the ISD analyst to describe how the intended trainer would be used to achieve the specified training objectives, practice or acquire the specified task performances, and present the specified malfunctions for isolation and/or correction. More specifically this section enabled the specification of:

   a. The problem classes to be presented by the trainer.

   b. The instructor activities required during given student exercises.

   c. The student activities required during given student exercises.

   d. The response of the trainer during given student exercises.

   Also this section provided an opportunity to specify the training environment surrounding the trainer; e.g.,

   a. The number of instructors envisioned to operate the trainer.

   b. A brief description of the facility required to house the trainer.

   c. A brief statement of the utilization of the trainer (number of operating hours per year).

   d. The identification of support equipment and materials.

3. Simulation Characteristics: This section of the initial draft provided an opportunity to specify:

   a. The physical characteristics of the equipment being simulated.

   b. The functional characteristics of the equipment being simulated.

4. Instructional Features: This section of the initial draft provided an opportunity to specify the computer-controlled or based instructional features required on the trainer, such as:

   a. Cue enhancement features.

   b. Augmented feedback features.

   c. Automatic scoring and recording features.

5. Trainer Configuration: This section of the preliminary draft provided the ISD analyst with an opportunity to specify:

   a. The overall configuration of the trainer (if the ISD analyst had one in mind).

   b. Relationships between the trainer and the facility (if any were known).

   c. Relationships between the components comprising the trainer (if any were known).

This preliminary statement of the ISD desired outputs was intended as the forerunner of the model ISD specification. The final version of the model ISD-derived specification was Maintenance Training Simulator Design and Acquisition: ISD-Derived Training Equipment Design. This model ISD-derived specification is discussed as a final product in more detail in another section of this report.

Comparison of Ought-To-Be Outputs to Actual Outputs

Given the initial statement of the ISD desired outputs (in a model ISD specification format), the project staff commenced to compare this with the actual or existing ISD outputs.

The results of the comparative analysis revealed the following:

1. Systematic procedures for selecting and describing such instructional features as malfunction insertion, cue enhancement, augmented feedback, and automatic scoring and recording capabilities needed to be forthcoming. The whole area of instructional features was poorly addressed by the 3306th procedures.

2. Improvements had to be made in the way physical and functional characteristics of the items to be simulated were determined and documented; i.e., there were no known available systematic procedures for determining levels of fidelity.

3. Procedures for determining when a simulator was absolutely necessary needed to be improved. In addition, a way to document this decision was needed.

4. Procedures for considering the whole training program or regime were needed before designing the maintenance trainer. The desired ISD outputs assumed that considerable thought be given to the entire training program before the characteristics of the training equipment were documented.

5. Improvements in the way skills and knowledge statements were written needed to be forthcoming. Frequently skills and knowledge statements were only duplicates of the task actions recorded on the task descriptions reported or provided by contractors. It seemed, to the project staff, that skills and knowledge statements should reflect what the student needs to know and do to display the action rather than just reflect what is done.

6. A mechanism was needed to identify:

   a. Software requirements.

   b. Areas where updates were going to be needed or at least identify where the trainers should be provided some flexibility.

As can be seen, the comparative analysis revealed many areas for improvements in the ISD process. The project, at this point, developed a plan for attacking the problems.

First, efforts would be concentrated on three areas:

1. Development of procedures for determining when a simulator or trainer is required for the attainment of specified learning objectives as well as a method for documenting such a decision.

2. Development of procedures for determining the physical and functional characteristics of the parts or components which are to be simulated (i.e., determination of fidelity levels) as well as a method for documenting such characteristics.

3. Development of procedures for selecting and describing instructional features as well as a method for communicating such decisions.

Next efforts would be devoted to:

1. Development of ISD procedures which would consider the whole or entire training program.

2. Improving upon the method for identifying and recording skills and knowledge.

And lastly, efforts would be concentrated on:

1. Deriving software requirements from the training equipment characteristics. It was felt that the specification of instructional features would help to determine most software requirements. For example, the need to have automatic scoring would, to some extent, indicate the nature of the software requirements.

2. Deriving from all requirement areas where flexibility in the trainer design would be useful.

Review of Current Training Technologies

The first step in the project plan was to review the existing literature of training technology to determine what technologies would or could be used. The approach was to look at procedures which would facilitate the determination of training equipment characteristics from task description and analysis data. It should be recalled that at the onset of the project a theoretical framework was postulated. That theoretical framework contended that from a taxonomy of behaviors, equipment characteristics such as levels of fidelity could be determined. The review was primarily designed to determine if such a theoretical framework was possible. The literature reviewed consisted of the models/techniques developed by:

1. R. B. Miller (1960).

2. Damanee (1961).

3. Willis and Peterson.

4. Folley and Chenzoff.

5. E. E. Miller

6. Shattel (1972).

7. Pieper (1978).

Because the conclusions of the review were discussed in Section I of this report, they will only be briefly presented here:

1. There was very little empirical evidence to support the relationship between a taxonomic element and a learning strategy or scenario.

2. There was no evidence to support a relationship between the learning strategy generated from the taxonomic element and training equipment characteristics, such as fidelity levels and the selection of instructional features.

3. Most of the taxonomic structures reviewed were appropriate for describing the behaviors of operators, but not for describing maintenance behaviors.

4. All the procedures or methods reviewed assumed the tasks to be practiced on the intended trainer were already identified and, as such, were of little value in determining whether or not a trainer was required.

The review of literature was not encouraging. It indicated that more educational and psychological research needed to be accomplished before such a simple theoretical approach would work.

However, the review was not seen as a useless exercise. Although the review indicated that there was in existence no single model or approach which could be used, it did provide the project staff with an abundance of information.

After the review of literature was conducted, the project staff felt confident that part of the review would be useful in developing a set of criteria for when a trainer would be required. The learning principles reviewed provided guidelines for when practice on some sort of trainer was needed. For example, practice would be required if the behavior required the student to make fine or precise adjustments. Such guidelines would assist the project staff to develop a list of questions one could ask themselves to determine if practice on a trainer would be needed or at least appropriate. Thus, the review was seen as providing the project staff with valuable information which could be tapped as the project continued.

Develop New Technologies

Given the review did not generate an already existing procedure or ISD process to identify training equipment characteristics from task analysis or task description data, the project set out to develop new technologies (or at least develop technologies which were adaptations of the existing learning principles). Before developing the needed training tools, the project staff innumerated the criteria or conditions which governed the development of these tools:

1. The tools had to be as mechanical as possible, e.g., easily described by flow charts.

2. The tools or procedures had to have their foundations in the empirical research that already had been conducted and reported in the literature.

3. The tools or procedures had to provide mechanisms for applying the theoretical principles discovered during the review of literature. That is, it was <u>not</u> enough for the tools to list the appropriate learning principles, the tools had to provide guidance on how these principles were to be applied.

4. As much as was possible the procedures or tools to be developed had to "fit" into the existing procedures developed and used by the 3306th. The project saw no need to re-invent the wheel or duplicate the procedures that were already developed. This did not mean that the existing procedures could not be modified. In addition, the procedures had to account for the variability of the data bases available to ISD analysts.

5. The tools or procedures had to document all training equipment design decisions made. Documentation would be needed to assure traceability in the decisions. Only through such traceability could improvements be made in the design phases of the acquisition process.

Given these major guidelines, procedures were developed. The procedures and/or tools developed by the project are reported in <u>Maintenance Training Simulator Design and Acquisition: Handbook of ISD Procedures for Design and Documentation</u>. This document is in two volumes. Volume I presents and discusses the procedures, while Volume II provides an example for how the tools are used. It should be stressed again that the project-developed ISD Handbook is a supplement to the 3306th <u>Procedural Handbook</u>; it is not meant to replace the 3306th <u>Procedural Handbook</u>.

The ISD steps presented in Handbook of ISD Procedures for Design and Documentation are reported in Table 1. Although each of the steps are described in considerable detail in that document, a brief description of each step is provided here. The descriptions provided in this final report should not be taken as complete or comprehensive. For the details necessary to conduct each step, the reader is referred directly to Handbook of ISD Procedures for Design and Documentation.

The first three steps are not substantially different than the existing steps in the 3306th process. In the fourth step, skills and knowledge are separated into two groups - those that require a maintenance trainer of some sort and those that can be acquired using some other type of media. This step is different from what occurs in the existing 3306th process. The fifth step is also new. It is in this step that consideration is given to how the maintenance trainer "fits" into the entire training program. This step forces the ISD analysts to sequence all the skills and knowledge that are to be contained in the entire training program. This sequencing forces the ISD analyst to consider how the intended trainer (as envisioned to this point in the process) is to be used. In accomplishing the fifth step, skills and knowledge originally classified in Step 4 may be reassigned; i.e., because of the sequence of skills and knowledge, skills and knowledge originally classified as being acquired by other media may be assigned to the trainer. After all the skills and knowledge to be acquired on the trainer are identified and the use of the trainer is clearly understood by the ISD analyst, fidelity level decisions are made. It should be pointed out that fidelity level decisions are only made for those skills and knowledge assigned to the trainer. After fidelity decisions are made, instructional features are selected. The next step, Step 8, requires the ISD analysis to prepare the model ISD-derived specification. Steps 9 through 14 are generally the same as originally described in the 3306th Procedural Handbook (June 1979).

For convenience, only Steps 1 through 8 will be discussed in this final report, since the remaining steps are almost the same as the steps described in the 3306th ISD process:

1. Identify System Maintenance Requirements. This step requires the ISD analyst to identify all system maintenance tasks to be performed on the new weapon system for which training is to be developed. The typical source for this identification is the Logistical Support Analysis (LSA) data, which is usually provided by the contractor. The LSA data is supplemented by speciality code data and course standard data.

   Tasks not described by the LSA data are recorded on a project-developed FORM 1. At this point in the process the

Table 1

Summary of Handbook Steps

STEP 1	Identify System Maintenance Requirements
STEP 2	Identify Characteristics of the Target Population
STEP 3	Determine Training Requirements
STEP 4	Determine the Type of Technical Training Materials Required
STEP 5	Sequence Skills and Knowledge (Utilization Plan)
STEP 6	Identify Fidelity and Simulated Features
STEP 7	Select Instructional Features
STEP 8	Prepare ISD Specification
STEP 9	Identify Method
STEP 10	Prepare Course Control Documents (CCD'S)
STEP 11	Prepare Instructional Materials and Tests
STEP 12	Validate Instruction
STEP 13/14	Conduct Training and Evaluate Training

ISD analyst is requested to group tasks by procedure, function, or equipment. This grouping facilitates both Steps 5 and 6.

2. Identify Characteristics of Target Population. This step requires the ISD analyst to identify the AFSC or the intended target population as well as the previous weapon system experience of that group. In addition, if possible the analyst is asked to project potential areas of negative transfer (areas where students who have had previous weapons system experience might find difficulty in performing tasks on the new system because of that previous exposure). It should be made clear that the next step in the ISD process cannot be conducted until the target population is identified and described. Training requirements cannot be identified in a vacuum; they are identified in light of the characteristics of the target population. If the target population changes, the procedures require the remaining step in the ISD process to be performed again.

3. Determine Training Requirements. To specify training requirements, the ISD analyst must know the characteristics of the target population (what skills and knowledge they can already perform) and the skills and knowledge required to maintain the operational system in question. The difference between these two sets of skills and knowledge constitute the content of the training program. Notice that if the target population is inadequately described, then the ISD analysis must be restarted from this step.

   The first step in this procedure is to identify the steps/activities of the tasks. These steps/activities are recorded on a FORM 1, if there is no LSA data. Next the steps/activities are analyzed to determine if they contain a potential training requirement. To assist the analyst in making this decision, a set of questions is asked (in a flow chart format).

   a. Is the step/activity new?

   b. Does the step/activity have an unusual condition associated with it (e.g., performed with limited access)?

c. Does the step/activity have an unusual criteria associated with it (e.g., performed in a short time span)?

d. Does the step/activity have a potential negative transfer problem?

e. Does the step/activity require a new support tool or test equipment to be used?

A "Yes" answer to any of the questions means the step or activity contains a potential training requirement. A "No" answer to all the questions indicates the step/activity can be already performed adequately by the target population and need not be included in the training program.

For those steps/activities that contain a potential training requirement, a process is performed to identify the critical skills and knowledge. Briefly this procedure consists of asking four critical questions:

a. What does a person need to know to perform the step/activity? (e.g., recall jargon, locate objects, name objects, describe objects, order objects or events, recall principles or facts, discriminate between similar objects or events, classify objects, use rules, make decisions, etc.)

b. What skill is required to successfully complete the step/activity? (e.g., coordination between limbs; quick movements to stimuli or inputs; special strengths or balance.)

c. Considering the task as a whole, is there any additional knowledge not reflected in each step/activity? (e.g., any special relationships between the steps/activities, any overriding principle or concept.)

d. Does the task as a whole, require any movement or manipulation related to all the steps/activities? (e.g., complete limited access, special conditions of balance, etc.)

These questions represent an improvement over the process currently used to identify skills and knowledge.

Also to assist the ISD analysis, a procedure was developed to identify the skills and knowledge associated with troubleshooting tasks (steps/activities). This procedure consists of first determining the nature of the troubleshooting:

a. Is the troubleshooting process documented in the T.O.?

b. Does the student need to know the logic of the system (either hardware logic or software logic)?

Next the ISD analyst is directed to a set of questions concerning the type of skills and knowledge associated with troubleshooting behavior. Since these questions are similar to the four questions listed above they will not be presented here.

The procedures for identifying skills and knowledge represented a new approach for the ISD analyst. The set of procedures to identify skills and knowledge was designed primarily to discourage the analyst from simply reporting the step/activity as the training requirement.

After identifying the set of skills and knowledge, the skills and knowledge are recorded on a project-developed FORM 2. For documentation reasons, each skill and knowledge is evaluated to determine if it is new to the target population. New skills and knowledge represent the population of training requirements.

4. <u>Determine Type of Technical Training Materials</u>. This step requires the ISD analyst separate the population of skills and knowledge into two groups - those which need to be practiced on a trainer and those which can be acquired using some other media (such as sound/slide, printed materials, etc.).

To assist the analyst in making this critical decision, the project staff developed a flow chart which asks the following questions:

a. Is the skills or knowledge difficult to execute? (e.g., are there many similar inputs to analyze; are there many responses to choose from; is precision or dexterity required?)

b. Is there an unusual condition indicating the need for practice? (e.g., coordination between team members, information being received under noisy conditions, little time between signal and required response, pace set by circumstances and not performer, performance in limited access required.)

c. Is there special criteria indicating the need for practice? (e.g., time or error specifications that cannot be met without practice.)

d. Are there hardware cues that affect performance? (e.g., are there dynamic cues or unique hardware cues which could not be learned without practice; are there any feedback cues which are critical, such as, visual, auditory or tactile cues; do slow but continuous changes have to be noticed?)

e. Does the skills or knowledge involve the use of new support tools or test equipment (exclude handtools)?

f. Are the consequences of errors high? (e.g., will an error result in possible injury to personnel or damage to equipment - if "Yes" then the skill or knowledge should be practiced on hardware.)

g. Is the skill or knowledge associated with an emergency situation? Is the skill or knowledge frequently required on the job? (Both situations indicate practice is required.)

Skills and knowledge leading to a "Yes" answer on any of the questions listed above are classified as being acquired on a trainer of some sort. This sort of decision logic was not currently available in the 3306th procedures.

In addition to providing decision logic for determining when practice on a trainer is needed, the project developed a procedure for determining the media class of the remaining skills and knowledge in the training requirement population. This procedure leads to the following media classes:

a. Audio/Visual.

b. Audio, only.

c. Moving Visual.

d. Still Visual.

e. Printed Material.

f. Computer assisted instruction.

The type of media in each class is also further defined in the ISD Handbook.

5. Develop Utilization Plan. Step 5 is a critical step in the ISD procedure presented in the project-developed ISD Handbook. This step requires the analyst to sequence all the skills and knowledge to be taught in the training program (both those assigned to the trainer and those assigned to other media). The purpose of this step is to force the analyst to think about the trainer in light of the entire training program. In addition, the sequencing was designed to help the analyst determine precisely how the trainer would be used as well as think about the environment which will house the trainer. As a result of performing this step, the analysts will:

    a. Obtain a better idea about the trainer (before it is designed).

    b. Sequence skills and knowledge within tasks.

    c. Sequence tasks within groups (the groups formed during Step 1).

    d. Sequence the groups of tasks.

    e. Perhaps adjust the assignment of the medias made during Step 4; e.g., reassign skills and knowledge to be taught on other media to the trainer class.

    f. Determine the number and type of trainers to be designed.

    g. Determine the instructor demand (number of instructors).

    The seven information categories above are recorded on a Utilization Plan Worksheet.

6. <u>Identify Fidelity and Simulated Features</u>. At this point in the project-developed ISD process, the analyst has:

   a. Identified the skills and knowledge to be acquired using the trainer.

   b. Available a sequence of skills and knowledge.

   c. "A feeling" for how the trainer is to be used.

Given this information, the ISD analyst is in a good position to determine the fidelity levels of the components to be simulated. It should be pointed out that in Step 4 of the project-developed ISD process, a decision is made concerning what skills and knowledge are to be acquired using the trainer. Notice that this procedure did not lead a decision concerning the type of trainer (e.g., a familiarization trainer or a part task trainer). The existing definitions of types of trainers were not standardized; i.e., the same labels meant different things to different people.

Therefore, it was decided to develop a procedure which generated fidelity decisions on a component by component basis rather than on a trainer by trainer basis. If a decision could be made determining the fidelity level of the components, then no label needed to be attached to the entire trainer. The trainer would have the fidelity level of the components contained on the trainer. In addition, this approach allowed the trainer to have different fidelity levels for different components.

Thus, the first step in determining the levels of fidelity is to identify all the components or parts associated with the skill or knowledge. Then for each component, a decision is made concerning the component's stimulus, response, and feedback characteristics. To assist the analyst in making these decisions the project staff developed a set of flow charts - one flow chart for each class of characteristics, stimulus, response, and feedback. For ease of understanding, these flow charts are presented in Appendix A of this report. Once a decision is made, it is recorded on a Task Fidelity Worksheet. For each component three fidelity decisions are required; one for the stimulus properties of the component, one for the response properties of the component and one for the feedback properties of the component. In addition to recording the fidelity

level decision on the Task Fidelity Worksheet, the actual property or characteristic to be simulated is also recorded.

Since different skills and knowledge within a task may require the use of the same component, there may be several fidelity level decisions for a given component. If these fidelity decisions (one for each stimulus, response, and feedback characteristic) are the same between skills and knowledge there is no problem. If they are different, then the differences must be reconciled. To reconcile the differences, a flow chart was prepared by the project staff for use by the ISD analysis. This flow chart is also contained in Appendix A. This flow chart results in determining the fidelity level of the component for the entire task.

There is also the possibility that a component may be used for several tasks. Because of this situation, a component may have different fidelity levels between tasks. If the analyst feels one fidelity level should be recommended for each component, then these differences must be rectified. To rectify these differences the same flow chart can be used that was used to rectify differences within a task.

The final operation in determining the fidelity level is to complete a FORM 3 (see Appendix A). FORM 3 allows the analyst to record the component to be simulated as well as record a description of the component. The description of the component must justify the recommended fidelity level as well as describe the stimulus, response, and feedback properties of the component to be simulated.

7. <u>Select Instructional Features</u>. This step like the previous step is complicated to describe. For a comprehensive discussion of how instructional features are selected, the reader is referred directly to <u>Maintenance Simulator Design and Acquisition: Handbook of ISD Procedures for Design and Documentation</u>.

It should be recalled that instructional features were defined as those features which could be computer-controlled. Step 7 refers only to these types of instructional features; instructional features such as the noise level, the size of the trainer (which influences its ability as a demonstration media), etc. are primarily handled in Step 5.

The project staff viewed the learning situation as involving four aspects:

a. Presentation of stimuli.

b. Measuring student responses.

c. Feedback concerning the responses.

d. Selection of the next activity.

Given these four aspects of the learning environment, the project staff reasoned that either the instructor could control them or the trainer (through a processor) could control them. When the trainer was assigned these controlling responsibilities, then the trainer was said to have computer or processor controlled instructional features; i.e., features which would help the trainer acquire certain skills and knowledge and would facilitate the instructor in managing the instruction.

Given these four aspects of the learning environment, the project staff initiated an effort to identify possible areas of control within each aspect. This was primarily accomplished by using the learning principles and behavioral scenarios discovered during the review of literature. The list that was generated is offered in Appendix B. For each instructional feature a brief definition is also presented.

To select the instructional features the trainer should have, the ISD analyst starts out by completing an Instructional Features Worksheet. The Instructional Features Worksheet asks a set of questions:

a. Who senses the student responses?

b. Who records the student responses?

c. Who scores the student responses?

d. Who reports the student responses?

e. Who monitors the status of the system as the student is engaged in a practical exercise?

f. Who controls the rate of stimulus presentation?

g. Who controls the ratio of signal-to-noise of stimulus being presented?

h. Who provides augmented feedback messages to the student?

i. Who controls the selection of the next activity?

To answer each question a flow chart is provided. The flow charts result in one of two possible answers; either the instructor controls or the trainer controls (via a processor) the aspects mentioned under consideration. The flow charts consider such issues as:

a. The availability of the instructor to control the aspects in question.

b. The difficulty which would be encountered by the instructor if he were to control the aspects in question. For example, if the response occurs rapidly or is difficult to observe because of the potential position of the student or the instructor, then the flow chart assigns sensing the response to the trainer.

c. The dependencies among the various aspects to be controlled (e.g., the trainer cannot score responses unless it also senses the responses).

For illustrative purposes an example flow chart is provided in Appendix B. The example provided in Appendix B concerns determining who senses the student responses.

After completing the Instructional Features Worksheet, the analyst selects the precise instructional features that are required. To assist the analyst in selecting these instructional features, a flow chart is provided for each feature. These flow charts, in general, require the following sources of input:

a. The decisions made and recorded on the Instructional Features Worksheet; e.g., who has control over sensing student responses.

b. The learning or behavioral scenarios provided (an example scenario is provided in Appendix B).

c. The stage of learning the behavior in question is to be acquired.

For illustration purposes an example flow chart is provided in Appendix B.

8. Prepare ISD Specification. Given the decision to have a maintenance trainer (Step 4), some idea of how the intended trainer will be used (Step 5), the fidelity levels of the components to be simulated (Step 6), and a list and description of the processor controlled instructional features (Step 7), the ISD analyst is ready to prepare the ISD model specification so that these decisions can be communicated to SPO personnel. Although the preparation of the ISD model specification is included as a step in the project-generated ISD Handbook, the model ISD specification and the instructions for completing it are bound in a separate document (Maintenance Training Simulator Design and Acquisition: ISD-Derived Training Equipment Design. The model ISD specification contains the same information categories as previously described in this report (see Appendix C for the table of contents of the model ISD specification).

In addition, the model specification was designed considering the following:

a. To assure that all the required features and/or characteristics of the trainer, as derived from the ISD analysis, were included in the statement that eventually went to the SPO, including a statement describing how the trainer would be used.

b. To contain blanks to be completed by the ISD analyst, such that only the information which would be applicable to a specific application of the model would be included in the communication; i.e., the ISD analyst had freedom in selecting the specific paragraphs and subparagraphs to include in the communication to the SPO (depending upon the specific training situation) and had an opportunity to tailor specific trainer requirements.

c. To be applicable for specifying maintenance training equipment requirements (including simulators) for both the organizational and intermediate levels of maintenance training.

d. To allow the ISD analyst freedom in completing the specification; i.e., there was no implied priority in completing a specific application of the model in the order in which the paragraphs and subparagraphs appeared.

e. The level of detail required by the specification was one judged ideal for purposes of assuring that the intended training device was procured meeting all the specified requirements. However, the model specification was designed such that more general levels of detail could be specified if resources did not permit a complete analysis. This provision was needed to accommodate the problem associated with an incomplete but expanding data base.

   This characteristic of the model ISD specification also permits the specification to be used in novel ways. For example, the ISD model specification can be used as a pre-TRRRM document to increase communication between the ISD analyst and the SPO prior to the time the ISD team must submit the final training equipment recommendations.

f. To allow training information as well as training equipment requirements to be communicated; i.e., not all the information included in the communication specified training equipment requirements or characteristics, some of the information provided by the ISD analyst would be used only to provide guidance to the SPO engineer and/or eventually the vendor.

g. To communicate the need to have the trainer be designed with flexibility in mind. That is, the model ISD specification was written to emphasize the need for flexibility, such as being able to create new malfunction exercises, to alter criteria values in scoring, etc.

The format of the model ISD-derived specification is unusual. The specification is generic, meaning that it can be used to communicate the requirements of many types and kinds of maintenance trainers (e.g., O-Level and I-Level trainers). In addition, the specification contains blanks (usually where a list of requirements is to be inserted). The blanks permit the specification to be tailored to specific situations.

Those items which would be standard across all situations do not contain blanks. This type of format allows many things to occur.

1. Paragraphs or subparagraphs can be deleted depending upon the specific situation.

2. The specification can be completed during the ISD analysis (i.e., the ISD analyst could complete those paragraphs and subparagraphs for which he had information), those for which he did not have information could be marked "To be determined." Thus, the specification evolves as the ISD analysis progresses.

3. Because of item 2 above, the specification could be used to communicate the results of the ISD analysis as they are known; i.e., at any given moment the ISD-derived specification could be used as a communication document - to communicate requirements to SPO personnel.

4. The format facilitates completing the specification. If word processing capabilities are available, the standard paragraphs and subparagraphs can be entered and be made ready for recall.

Because of the format of the specification, a set of instructions had to be prepared for using the model ISD-derived specification. The instructions provide guidance on the following:

1. Guidance on selecting the appropriate paragraphs and subparagraphs to include in the specification so the specification could be tailor-made. Each paragraph or subparagraph has its own set of instructions.

2. Guidance on completing the blanks - typically, this guidance involves inserting certain forms form the ISD-Handbook or it involves guidance on how specific requirements can be derived and/or stated (phrased), often suggested phrasing is provided.

3. If the training requirement being discussed is influenced by Military Standards and regulations, those standards and regulations are sited.

4. The instructions provide guidance by discussing some lessons learned from previous training equipment acquisitions. Typically, this discussion presents cautions or justifications; e.g., the problems experienced in the past by specifying that the contractor or vendor should

determine the number of malfunctions the trainer is to present.

For completeness, some pages from the set of instructions are provided in Appendix C.

To give the reader a "feel" for what the model ISD specification looks like some pages from the specification are provided in Appendix C.

ISD-Team Training

After the model ISD-derived training equipment design specification and the ISD Handbook (which presented procedures for generating the information to be inserted into the application of the model specification) were completed, both were field tested on an ISD training group. The target audience selected was the 3306th T&ES. This audience was selected for several reasons:

1. They were familiar with their own ISD process, which served as the baseline for the project efforts; i.e., the project-developed ISD Handbook was designed to be a supplement to the materials presented in the 3306th Procedural Handbook (June 1979).

2. The project staff had worked closely with the 3306th during the life of the project. Members of the 3306th ISD team were often consulted during the development of the flow charts depicting how design decisions should be made.

3. The 3306th was extremely interested in the project. They were eager to see improvements in their procedure and they recognized the need to have improvements.

4. The 3306th represented the type of personnel (end-users) who could benefit from the training and begin immediately applying and using the decision-making flow charts and the model ISD-Derived Training Equipment Design specification.

The training was designed to meet the following objectives:

1. To provide the trainee an opportunity to become familiar with the procedures offered; i.e., to actually use them.

2. To provide the trainees an opportunity to suggest modifications in the project-generated ISD Handbook and in the model ISD specification; i.e., to critique the materials.

To prepare for the training, a training course outline was constructed. The outline contained the terminal objectives of the training, a description of the target population, lesson objectives, and lesson content outlines. The training also contained 15 practical exercises.

A three day session was conducted at Edwards Air Force Base, California. The participants consisted of 14 members of TES staff including both experienced ISD analysts and individuals just recently assigned to Edwards AFB.

Modification in ISD-Materials

The participants in the field test provided useful suggestions for improving the project-developed ISD Handbook and the model ISD specification.

As a result of the field test, some of the forms and flow charts were modified. The modifications, however, were slight. After all revisions were made, the final version of the project-developed ISD Handbook was submitted.

The modifications made in the model for documenting the ISD-derived training equipment design were also minor. The ISD analysts felt that an introduction to the document would help put the model specification into its proper perspective. The introduction:

1. Discusses the limitation of the model ISD specification; i.e., describes how the completion of the paragraphs and subparagraphs requested in the model are dependent upon the quantity and quality of the task data and the time available to complete the ISD analysis as well as make training equipment design recommendations.

2. Discusses how the model ISD specification can be used as a pre-TRRRM document to stimulate or encourage more contact and communication between the ISD team and SPO engineer during the ISD analysis. That is, the model specification is designed to be completed in sections or in parts which allows the ISD analyst to supply partial information (which can at a later date be updated). The partially completed model specification can be forwarded to SPO to stimulate further discussion.

SPO Project Activities

Summary of Current SPO Procedures

Interviews with SPO personnel revealed the following major steps in the SPO process:

1. Validate the training equipment function and design characteristics documented as a result of the ISD process.

2. Determine the feasibility of the validated equipment requirements in terms of available monetary resource estimates, delivery time requirements, and engineering state-of-the-art.

3. Present justification rationale to the SPO Program Director for approval of need and allocations.

4. Prepare Statement of Work (SOW) and Request for Proposal (RFP) documentation detailing the management approach applicable to contractor activities.

5. Evaluate proposals based on technical approach, understanding of requirments, innovations toward satisfying goals, timely product delivery, experience, facilities, personnel resources, and cost.

6. Reevaluate and finalize details of the procurement specification to assure concurrence with every specific requirement, emphasizing to the contractor that the rigorous test, acceptance, and checkout procedures contained in the specification will be strictly enforced.

7. Monitor, within contractually legal bounds, the developmental and production process to assure equipment and timeliness of equipment delivery.

8. Supervise and participate in the specified test, acceptance, and checkout activities. Coordinate using command and expert engineering support to assure that the maintenance training equipment meets requirements.

A critical review of these activities lead to the identification of three problem areas:

1. Variable Management Practice. Lack of consistent organization among SPOs has resulted in varying degrees of program support to maintain training equipment management and

subsequently to variable training equipment quality. (This problem area will be minimized by the implementation of SIMSPO.)

2. Lack of Procedural Guidance. Two primary directives used in the acquisition of maintenance training equipment are MIL-T-81821 and MIL-T-23991E. These directives place requirements for values and functional fidelity, which can adversely affect the ultimate cost-effectiveness of maintenance trainers. These directives also necessitate extensive justification efforts if their specified requirements are deviated from to achieve enhanced instructional value.

3. Late Acquisition. Late acquisition is due to several related factors; e.g., late receipt and lack of completeness of engineering and task data provided to the ISD team, insufficient manpower available among engineering advisors (whose time is being shared among several programs), and a high turnover rate among SPO Acquisition Managers (due to military transfers).

A summary of the current SPO procedures appears in AFHRL-TR-79-23, <u>Maintenance Training Simulator Design and Acquisition: Summary of Current Procedures</u>.

After the review of the SPO process and the identification of the problem areas, the decision was made to concentrate the project efforts on developing a generic or model SPO specification.

The emphasis on the development of a model or generic SPO specification required close coordination with the development of the model ISD specification. It was desired that the two specifications be integrated in a reasonable fashion. It was anticipated that the model ISD specification could be a legal attachment to the prepared SPO specification.

Specify Content of Model SPO Specification

An initial draft was prepared which contained 7 major content areas, reflecting both training related requirements and engineering requirements:

1. Scope (items to be provided, data to be provided, and services to be provided).

2. Applicable Documents (Military Standards, Specifications and other publications).

3. Requirements (Operational System Definition, Trainer Definition, Contractor-Furnished Equipment, Training

Capability, Reliability, Maintainability, Physical Characteristics, Environmental Conditions, Parts, Workmanship, Safety, Logistics).

4. Quality Assurance (Responsiblity for Tests, Review and Inspection, Test Plan, and Warranties).

5. Preparation for Delivery (Air Transportability, Detailed Preparation).

6. Notes.

7. Attachments.

The model SPO specification was designed with the following features in mind:

1. It was written in a Military Specification format. The major paragraph headings conformed to MIL-STD-490.

2. It was designed to maximize the degree of engineering design latitude left to the trainer manufacturer without jeopardizing training effectiveness.

3. It was designed to enable the incorporation of the model ISD specification (to avoid distortion and misinterpretation of the ISD-derived training requirements).

4. The model specification was written to incorporate appropriate Military Specifications and Standards in a general sense, but to avoid the problems of over-or-under designing the engineering features of a training device on the basis of standards or specifications written originally to prescribe the characteristics of operational equipment.

5. The model specification was configured to be a performance specification; i.e., the parameters to be inserted by the SPO engineer dealt with performance characteristics.

6. The model SPO specification was designed to accommodate trainers for both I- and O-level maintenance personnel.

7. The model SPO specification was designed in the same format as the ISD-derived model specification; i.e.g, it should:

    a. Be generic (appropriate for various types and kinds of trainers).

b. Include all possible paragraphs and subparagraphs which any situation might require.

c. Provide blanks so that requirements can be tailored.

8. The specification had to permit traceability; i.e., every requirement to be specified in the specification had to be traced to either a Military Standard or to one of the flow charts for the ISD-Handbook.

Review Content of Preliminary Model SPO Specification

The preliminary draft of the model specification was then reviewed by SPO engineers to assure that the content was an accurate representation of what was required in a procurement specification. Suggestions were made for improving the draft of the model SPO specification. The suggestions primarily consisted of adding subparagraphs to the model, which reflected a more precise nature of the performance characteristics of the intended trainer; i.e., SPO engineers felt that a greater level of detail was required in the model.

Modifications were made and a second preliminary draft of the model specification was written (in an outline format). The outline was then reviewed again by SPO engineers.

Specify Content of SPO Handbook/Appendix

After the content of the model SPO specification was established, efforts began on developing a SPO Handbook/Appendix to accompany it. The purpose of the Handbook/Appendix was to provide the SPO engineer with a set of instructions on how to apply the model SPO specification in a specific application; i.e., how to select the appropriate paragraphs, how to complete the blanks, etc.

An outline of the Handbook/Appendix contained the same paragraph and subparagraph headings as the model specification. For each paragraph and subparagraph heading, the Handbook/Appendix contained a discussion of:

1. Rationale and Guidance. This is a discussion of why the paragraph or subparagraph was contained in the model specification. It provided the engineer with a justification for retaining or deleting the paragraph or subparagraph in a specific application.

Often included in this section of the SPO Handbook/Appendix was a discussion of the kind of information that should be inserted in the blanks. For example, in the interface paragraph, a discussion of the possible interfaces to consider is presented (such as external and internal interfaces).

2. Performance Parameters. This is a discussion of the possible performance parameters that could be entered in the blanks by the SPO engineer. It contains a laundry list of possible performance characteristics found in Military Standards and Specifications. Where a conflict existed in Military Standards or Specifications, the conflict is pointed out and both references are given. No attempt is made to resolve the conflicts.

   Often specific wording is suggested for specific performance parameters. This occurs particularly where a new performance parameter or value is suggested.

   Also included in this section is a discussion of how the ISD-derived design document could be used to specify some of the performance parameters.

3. Background and Sources. This contains a list of references for specifying the performance value; i.e., a list of references the engineer should read before attempting to specify the requested performance value. Often the original source of the requirement is given.

4. Lessons Learned. This contains a discussion of what has been learned either about a specific performance requirements or the way the specific requirement is stated. The lessons learned category was included to provide an opportunity to communicate the Air Force history in acquiring maintenance trainers. The lessons learned provide the engineer an opportunity to take advantage of the mistakes and/or good experiences made in the past acquisition efforts. It is in this section of the Appendix/Handbook that such issues as the following are discussed:

   a. The need to design the trainer for updateability (i.e., the need for the trainer to be kept current with the operational equipment). The ability to update both the hardware and software components of the trainer are discussed.

b. The need to make provisions for describing how the trainer will be used is reemphasized.

c. The specific ways that have been used in the past to state and describe the malfunction insertion capability are reviewed. A specific strategy for identifying malfunctions is also provided.

SPO Orientation Training

The model SPO specification and its accompanying Handbook/Appendix were given an informal field trail. The goals of the trial were as follows:

1. To provide the engineers and opportunity to again review the model SPO specification and its accompanying Handbook/Appendix.

2. To provide the engineer an opportunity to suggest improvement in both the model specification and its accompanying Handbook/Appendix.

3. To provide the engineers experience in using the ISD-Derived Training Equipment Design document to prepare an application of the model SPO specification.

All participants were from ASD/EN, Wright-Patterson Air Force Base, Ohio.

Modification to SPO Materials

As a result of the field test, modifications were made in the model SPO specification and its accompanying Handbook/Appendix.

The modifications in the model SPO specification were minor and consisted of making provisions for more blanks (i.e., spaces which allow the engineer to tailor the model to a specific application). For example, provisions were made to allow the engineer to specify either a firm date or an event for the date of applicable document.

Also a paragraph and several associated subparagraphs were added concerning software requirements. The ISD model specification does not deal with establishing or setting software requirements (in general, ISD analysts feel they are not qualified to make such decisions). As such, the identification software requirements were left to the SPO engineer.

The SPO Handbook/Appendix was also slightly modified. The modification primarily consisted of expanding upon the lessons learned category (i.e., more corporate Air Force history was documented) and expanding upon the rationale and guidance category (so that more guidance could be gained in determining the appropriateness of specific paragraphs and subparagraphs).

In addition, the SPO Handbook/Appendix was modified to reflect the software/courseware paragraph and subparagraph that were added. The guidance given the Handbook/Appendix stressed the need for the software/courseware to be modifiable and flexible; i.e., give the Air Force the opportunity to create new malfunctions and insert other controlling data or parameters.

The final version of the model SPO specification and Handbook/Appendix appears in a project document, Maintenance Training Simulator Design and Acquisition - Prime Development Specification for Maintenance Training Simulators (April 1980). For illustration purposes an example of the specification and Handbook/Appendix appears in Appendix D of this report.

SECTION III

REACTION TO PRODUCTS

Introduction

The project produced three documents which were designed for two types of end-users:

1. Maintenance Training Simulator Design and Acquistion: Handbook of ISD Procedures for Design and Documentation (final version, March 1980). This product was designed for ISD analysts. This Handbook provides a series of job aids to assist the ISD analysts to determine if a simulator/trainer should be used. In addition, it assists the analyst in identifying and documenting the training design requirements of the trainer.

2. Maintenance Training Simulator Design and Acquisition: ISD-Derived Training Equipment Design (final version, December 1980). This product was designed for ISD analysts to be used in conjunction with the project-developed ISD Handbook. This document is a model or generic specification used by the ISD analyst to communicate the ISD-derived training equipment requirements to the SPO personnel.

3. Maintenance Training Simulator Design and Acquisition: Prime Development Specification for Maintenance Simulators (final version, April 1980). This is a model or generic speicification used by the SPO engineer to develop a procurement specification. This document also contains an Appendix/Handbook which provides instructions for tailoring the generic specification for a specific application.

The reactions to each of these products is discussed in this section of this final report.

Handbook of ISD Procedures for Design and Documentation

The purpose of this document is to present the techniques developed to make critical instructional design decisions. The document was designed to supplement the 3306th Procedural Handbook. The Handbook of ISD Procedures for Design and Documentation was well received by the participants in the field test. Some of the comments made by the participants were:

1. "... many new and significant aspects to the use of ISD for training equipment determination were presented ... ."

2. "Of particular interest ... were the sections on media/fidelity determinations and instructional features selection. I feel confident that many aspects of these categories will be implemented and utilized by this organization ... ."

3. "The procedures developed ... definitely go beyond those in existence ... the end product would be much better than it is now." (The end product refers to the fabricated and delivered maintenance trainer.)

4. "Hopefully, many of these procedures will be incorporated into our procedures in order to better identify training and training equipment."

5. "The program as developed ... is a reasonable program and I feel is good for someone who has absolutely no preivous experience in the ISD process."

6. "The bottom line is that I believe the system is workable ... ."

7. "The flow diagrams used throughout the book are excellent."

Although the above comments are not scientific evidence, the comments do illustrate that the end-users see some value to the procedures (new technology) and are willing to try them. In fact, the 3306th has made a commitment to try the new procedures on an existing project.

Not all the comments were favorable. Most of the unfavorable comments centered around two issues - the amount of documentation required by the new procedures and a fear of the new procedures being mandated. For example, the documentation problem emerged in the following comments:

1. "... with due consideration for the realities of 'compressed' acquisition programs, efforts must continue which will result in the reduction of required documentation without sacrifice to the quality of the product ... ."

2. "... and if time was not a constraint and individuals did not object to the voluminous amount of forms ... ."

3. "... the documentation ... is ... an excessive amount of paper work for the type of training concept here at Edwards. To develop the trainer using the method presented requires additional manpower."

4. "There are too many areas documented ... ."

The fear of the procedures being mandated did not emerge in any written comments made by the students, but represented a substantial concern during the ISD team training course.

It is agreed that the ISD procedures developed by the project require considerable documentation. However, this documentation was built into the system to increase traceability.

ISD-Derived Training Equipment Design

The purpose of this document was to provide a vehicle for communicating the results of the ISD analysis to the SPO engineers. In the past, a formal document was not prepared. The ISD-Derived Training Equipment Design (model specification) was designed to facilitate the communication, so that the ISD-derived design would not be distorted when SPO engineers prepared the procurement specification. In this respect this document has two end-users; the ISD team who completes the specification and the SPO engineer who uses the completed document to prepare the specification that goes to vendors or contractors.

Perhaps the comments of one of the ISD analysts who participated in the project ISD team training best summarizes the feelings about the ISD model specification - "The specification ... is an article that has been needed for a long time, it will be put to good use." There were no unfavorable comments concerning the model ISD specification by the ISD analysts who attended the project training course.

The SPO engineers who will use the prepared ISD model specifications, reviewed the model specification but have not seen a prepared

specification; i.e., one completed by an ISD analyst. They, however, feel confident that the ISD analyst's input via the model ISD specification would greatly improve the quality of the procurement specification.

Prime Development Specification for Maintenance Training Simulators

The purpose of this model SPO specification and accompanying Handbook/Appendix is to provide guidance to the SPO engineer who prepares the final procurement specification. This model SPO specification contains both training requirments and engineering requirements where the training requirements are derived directly from the prepared ISD model specification.

The reaction of the participants in the SPO field test was positive toward the model SPO specification and its accompanying Handbook/Appendix. In fact, some of the engineers felt that parts of the model specification could be used in the development of other prime development specifications (e.g., the engineers suggested that the design and construction section of the model specification would be applicable to include in the Prime Development Specification for flight simulators).

Summary of Reactions

It should be stressed that the reactions reported above are initial reactions. As the materials are used by their respective audiences for actual acquisition projects, more reactions would be forthcoming. Some provision should be made for documenting these later reactions and for modifying the existing materials according to those reactions.

It should also be mentioned that the reactions reported above should not be taken as scientific evidence of the utility and validity of the project-developed materials. Such an evaluation could only be achieved by having the users use the materials. The time constraints inherent in the project prohibited such an evaluation. In addition, the reactions reported above should be moderated by the fact that both intended audiences (ISD analysts and SPO engineers) were continually involved in the project and participated in extensive review of the materials as they were being developed. Thus, their reactions, although not scientific, should carry some weight.

The reactions above were specific to each project-developed product. However, it is worthwhile to note that the project as a whole was well received by the participating groups. That is, one of the side effects of the project concerned the increased communications between SPO engineers and ISD analysts. Even if the products were not well received by their respective audiences, the project in and of itself had some real and tangible results. It is hoped that this level of communication and degree of cooperative spirit will continue after the project is over.

In summary, the following reactions were evident:

1. The project-developed ISD procedures for designing and documenting training equipment requirements were envisioned as involving a lot of paperwork.

2. The concept of having two specifications, one to document the ISD-derived training equipment requirements and one suitable for distribution to contractors and vendors, appeared to be reasonable and workable. Both SPO engineers and ISD analysts felt that the two specifications would guarantee that the ISD-derived requirement would not be misinterpreted or distorted in the procurement specification.

3. There was general agreement that the developed materials (particularly the specifications) attended to the critical issues; i.e.,

    a. They were comprehensive and complete.

    b. They made provisions for taking advantage of what has been learned in previous acquisition projects (particularly updateability of both software and hardware).

    c. They made provisions for including in the procurement specification, a statement concerning how the intended trainer is to be used in the classroom situation (the training environment) by the instructor.

    d. They covered the issues of - determining what tasks should be acquired on a trainer, determining the degree of fidelity of the components to be represented on the trainer, and determining the need for processor controlled instructional features to help the instructor manage the training.

4. The ISD analysts, in general, agreed that the project-developed materials represented an improvement over the existing materials to identify and document training equipment requirements.

5. Both SPO engineers and ISD analysts were favorable to the format of the model or generic specifications. They felt that the specifications provided flexibility (in completing the blanks), but still would standardize the presentation of requirements.

The first reaction summarized above needs further clarification. Although there was the feeling that a lot of paperwork was required, it was generally realized that the amount of documentation required was needed in order to facilitate the tracing of the requirements; that is, in general, documentation was seen as desirable. However, it was suggested that the documentation efforts could be minimized by using a micro processor (not only to process words, but also to process data). It was realized that the ISD materials were already in a flow chart format and, thus, could be easily programmed to be processed by a small computer. Further, it was realized that all the outputs of flow charts evenually appeared in the ISD-derived specification; i.e., the flow charts generated requirements which eventually appear in the specification. For example, the flow charts require the analyst to document occasions of potential negative transfer. Furthermore, the specification provides a paragraph where the occasions of potential negative transfer are specified or listed. It was realized by the groups involved that a word processor would be able to store the occasions of negative transfer as well as transfer these occasions directly into the prepared specification. That is, a processor would not only be a valuable aid in keeping track of data (ISD data), but would also be a valuable aid in actually preparing the ISD-derived specification. ISD data stored in the processor could be easily retrieved and inserted into the blanks of the model specification (all electronically and automatically).

This same reasoning can also be carried to the SPO side of the acquisition process. It should be recalled that much of the SPO specification is a direct transfer from the ISD-derived model specification. That is, much of the information in the SPO specification originates from the ISD-derived specification. If the ISD-derived requirements are electronically handled, then it makes some sense to suggest that preparation of the SPO specification also be electronically handled. The ISD-derived requirements electronic specification could be electronically transfered to the SPO specification.

SECTION IV

PROBLEMS, RECOMMENDATIONS, AND FUTURE RESEARCH

Introduction

Throughout the project several problem areas continually emerged. For example, interviews with ISD analysts always resulted in a discussion concerning the time available to perform the ISD analysis; i.e., ISD analysts felt that the acquisition cycle frequently did not permit sufficient time to conduct a complete and comprehensive analysis. In fact, the 3306th Test and Evaluation Squadron has recently declined an offer to participate in a program because they strongly felt that there was not sufficient time to perform the ISD analysis and, thus, they could not generate sound training equipment recommendations. Several problems such as this were frequently mentioned. In addition, during the project the staff recognized a few problem areas as well as potential solutions. Thus, in this section of the report these problem areas are addressed along with recommendations and areas for future research. The problems discussed below are not presented in any particular order.

ISD Analysis Compression

Because of accelerated acquisition cycles, ISD analysts are being requested to shorten the time it takes to perform the ISD analysis and to provide training equipment designs and requirements. In the past it has been desirable to have the training equipment, the maintenance trainer, available when the weapons system become operational. This often requires that the ISD analysis be started while the operational equipment is still in a state of evolution. By shortening the time available to do the analysis, the problem is compounded.

Several solutions to this problem exist. The solutions will be discussed below. These solutions are not presented in any particular order of preference:

1. It is perhaps reasonable on the surface to suggest that more manpower be made available to perform the ISD analysis. Currently at the 3306th, typically one person is assigned to one project or one system of the entire weapons system. It is intuitively appealing to believe that if

more manpower were available the ISD analysis could be completed in less time. However, it should be recognized that the ISD analysis is dependent upon the availability of the data base. Often the data is provided to the analyst in a staggered fashion. That is, the analyst may receive a lot of data in one month and no more data until two months later. If this condition prevails, then additional manpower may be of little help in performing the analysis on a shortened or compressed schedule. The contribution of additional manpower needs to be investigated.

2. An analysis of the situation reveals that 7 Level personnel, skilled technicians, are given conversion training to maintain the operational system when it is first delivered. 7 Level personnel, typically, have experience with a similar weapons system and minimal training is required to make them proficient on the operational system. In addition to 7 Levels, some 5 Level personnel, skilled maintenance personnel, are also given conversion training. At some point downstream 3 Levels, apprentice maintenance personnel, are trained to maintain the system. Currently the maintenance trainer is scheduled to be delivered and operational when the weapons system becomes operational. That is, the maintenance trainer is used during the conversion training. It has been suggested that one way to increase the time available to perform the ISD analysis is to use actual equipment during the conversion training rather than the maintenance trainer. Using actual equipment during the conversion training would give the ISD analyst more time to design the maintenance trainer. This approach seems reasonable, given that:

    a. It is assumed that 7 Levels can learn effectively on actual equipment (this assumption seems warranted since 7 Levels are typically familiar with a similar weapons system).

    b. Actual equipment is available during the conversion training phase; i.e., that down equipment can be used for training purposes.

    c. 3 Levels would benefit the most from the maintenance trainer; i.e., of the levels involved it seems reasonable to suggest that the 3 Levels would need the trainer more so than the others.

   This approach to the problem would mean that the trainer would not have to be delivered until 3 Levels are to be

trained. This would give the ISD analysts additional time to design the trainer. ISD analysts estimate that approximately a year could be gained in the design process. Given this additional time, a fairly complete and comprehensive ISD analysis could be performed. In addition, it is quite conceivable that the conversion training itself would provide additional information which could be used during the maintenance trainer design phase. That is, the conversion training and familiarity gained with the operational equipment during this time might provide insights into how the trainer could be more effectively designed and used. Thus, the conversion training experience might make it possible to design a more training-effective and cost-effective trainer.

This solution should be investigated to determine its feasibility. For example, information needs to be gathered to determine if 7 Levels can be effectively trained with actual equipment, if operational equipment can realistically be used for training purposes and how much time can be made available for performing the ISD analysis.

3. Another solution to the problem is to investigate the possibility of shortening the ISD process. It may be possible to develop a compressed ISD process without sacrificing the quality of the end product. For example, the project-developed ISD process might be able to be shortened by considering a higher level of detail in the behavioral analysis than the skill and knowledge level. It also seems possible to shorten the project-developed ISD process by reducing the amount of documentation required (via word or data processor).

In summary, three solutions to the problem of decreased time available to perform the ISD analysis are increased manpower, increased time through providing actual equipment during conversion training and a decrease in the amount of analysis performed. These solutions should not be considered mutually exclusive; i.e., there may be some advantage gained in applying two or three of the solutions simultaneously, as a package.

Communications

Interviews with both ISD analysts and SPO engineers always included a discussion concerning the possibility for increased communication between the two groups. Although the project is seen as

increasing the amount of communication between ISD and SPO personnel through the ISD-Derived Training Equipment Design document, it has often been suggested that teams be formed to design and acquire the maintenance trainer. Further, it has been suggested that the team be located at one institution and be composed of personnel from:

1. The 3306th T&ES (to provide the ISD analysis).

2. The SPO (to provide engineering assistance).

3. AFHRL/TT (to provide human factors and learning principle guidance).

It is felt that such a team approach would result in a much better end product; a much better maintenance trainer. SPO personnel could provide assistance in determining what is and is not feasible. AFHRL/TT personnel could provide ISD analysts with theoretical information concerning how people learn. It should be recalled that ISD analysts are skilled maintenance personnel, who have typically been maintenance instructors. To some degree they feel they need additional instructional and educational guidance. AFHRL/TT could provide such guidance as well as provide guidance on the current state-of-the-art of simulator design.

Although the team approach makes good sense, because it provides a core of experts, there are some practical problems which need to be addressed.

1. The team approach would require some personnel to be co-located, if the team were to be stationed at one location or facility.

2. SPO engineers are not typically assigned to one project; i.e., their time is shared by several projects. By assigning them to one team, this type of sharing might not be possible.

3. A structure for the day-to-day communication would have to be established.

4. Additional AFHRL/TT personnel would be needed; currently AFHRL/TT is not set up to provide such a service.

As an alternative to the team approach (involving co-location), it seems reasonable to suggest scheduled periodic meetings among the three groups; e.g., SPO personnel and AFHRL/TT people should be involved in

the pre-TRRRM meeting, as well as meetings which precede the pre-TRRRM meeting. Perhaps through more frequent meetings, communications could be increased. An increased meeting schedule, however, would require that TDY monies be set aside solely for such meetings.

ISD Staffing and Experience

Prior to being assigned at the 3306th T&ES, few ISD analysts have had the opportunity to participate in a large-scale maintenance trainer development project. During their stay at the 3306th, the ISD analysts are given some training and receive a tremendous amount of experience in designing maintenance trainers. Typically, their experience is acquired by working on one weapons system. After the maintenance trainer is designed, as well as the maintenance training program, ISD analysts are typically transferred to other assignments (a non-ISD assignment) and a new group of ISD analysts are brought in. It seems that a longer stay at the 3306th would benefit the Air Force. The amount of experience gained in developing one maintenance trainer can be transferred to the development of future trainers. It seems just as an ISD analyst begins to feel comfortable with his job and has learned from his experience, he is transferred to another assignment. Such a transfer policy does not take full advantage of the experience the ISD analyst gained. In addition, with such a transfer policy it is difficult to retain corporate knowledge. New analysts who come in cannot easily benefit from others' experiences (and mistakes).

In addition to staying longer, some consideration should be given to providing more structure to the ISD analyst's experience. Some analysts feel that their job is over when training equipment recommendations are made and the training program supporting the maintenance training equipment is designed. It seems that more could be gained by having the ISD analyst follow the training equipment and the training all the way through. That is, analysts should:

1. Be involved when the maintenance trainer is being fabricated. In this way it can be assured that design requirements are being met and the intended use of the trainer is being considered by the vendor.

2. Participate in the quality assurance testing of the device to assure that the device is designed according to the results of the ISD analysis.

3. Participate in the training program which uses the device to assure that instuctors are using the device the way it

> was intended to be used. During the ISD analysis, ISD analysts should be forced to assume the role of instructors who will eventually use the device. By participating in the training program that uses the device, the analyst would get a feel for potential inadequacies in the design, as well as the difficulties encountered in using some of the features of the device. This experience would be invaluable when the analyst again becomes involved in the design of a maintenance trainer.

After being exposed to such experiences, the analyst should return to the 3306th and be given an opportunity to participate in the design of another maintenance trainer. It seems reasonable to assume that this process would result in better trainers being designed, since initial errors and mistakes can be corrected, or at least avoided, during this design of the analyst's second maintenance trainer.

Current State-of-the-Art Exposure

In addition to broadening the ISD experience as suggested above, provision should be made to expose the analyst to the current state-of-the-art of maintenance trainer capabilities. Often analysts, when assigned to the 3306th, have a limited amount of exposure to what can be done with a maintenance trainer; what instructional features can be provided and how trainers can be used. As a result, analysts tend to design trainers according to their limited experiences and exposure.

Lt. Col. Stoughton, at the 3306th, has attempted to solve this problem by instituting a program in which vendors could come to the 3306th to show their designs, features, and anticipated capabilities. This program has met with little success. Vendors, surprisingly, have not accepted invitations to participate in the program.

As an alternative, consideration should be given to sending analysts to see other Air Force and military maintenance trainers. Perhaps such exposure would broaden the analyst's frame of reference, as well as highlight some of the problems that have been encountered in using the developed trainers; i.e., corporate history could be transferred relatively easy. This approach, however, is more costly than having vendors come to the analyst and, again, TDY money would have to be allocated for this purpose.

To keep the analysts current, consideration should be given to providing the analysts access to a laboratory (perhaps located at the 3306th T&ES). This laboratory could contain a generalized simulator,

perhaps driven by a mini- or micro-computer. This might assist the analysts in designing better maintenance trainers. The analyst could manipulate the computer to see if certain things could and could not be done.

Access to such a set up might be an expensive proposition, but it should be realized that the computing capabilites can be used for other purposes; e.g., the processor used to drive the generalized maintenance trainer could be used to help the ISD analysts document training equipment design decisions (thus reducing the amount of time required to do the documentation). In addition, the processor could be used to manage the task description and task analysis data. Given these additional uses for such a system, the cost may be more justified by tremendous benefits.

Engineering Change Proposal Analysis

It should be recalled that the ISD-Derived Training Equipment Design (model ISD specification) contains a paragraph concerning the prediction of possible engineering changes in the operational equipment. The purpose of this paragraph in the model specification is to alert the vendor or contractor to areas that might change, where the change impacts upon the maintenance trainer and maintenance training. If the vendor is alerted to these areas, he could perhaps design certain components in a modular fashion so that they could be easily updated.

To assist the analyst in predicting changes, a study should be conducted of the past engineering change proposals (ECPs). Such a study should concentrate on:

1. Providing information concerning where most of the changes in the operational system take place as well as the nature of those changes (e.g., a change in location of displays and controls vs. a functional change).

2. Determining if those changes impact upon maintenance trainers (i.e., did those changes result in modifications in the maintenance trainer and/or the training program).

3. Determining if changes involve trainer software modifications.

In this way, changes can be classified according to some reasonable scheme and the probability of the change can be estimated. Such information would provide considerable guidance to the ISD analyst and SPO engineer in developing a procurement specification.

Along with classifying the engineering changes, suggestions should be given for accommodating those changes. For example, suggestions can be given to the vendor concerning how modularization can be achieved, how labels can be used instead of photoetching, how software can be designed to accommodate functional changes (e.g., file structure design, etc.). This aspect of the study would involve gathering information from vendors concerning the state-of-the-art of such things as durable mastics.

One ISD Handbook

The project-generated ISD Handbook is a supplement to the 3306th Procedural Handbook (June 1979). During the training conducted under this project, the ISD team participants suggested that both ISD Handbooks be integrated into one comprehensive document. At some point in time efforts should be directed toward this goal. However, it seems reasonable to suggest that this be postponed until the ISD analysts become more familiar with the projectgenerated procedures. During this familiarization period, modification may be made and the procedure can possibly be shortened (compression of the ISD analysis). But it does seem advantageous, at some point in time, to develop only one handbook.

Contractor-Provided Data Base (LSAs)

Currently the data base available during the ISD analysis is provided by the contractor. This data base is verified and modified by the ISD analysts. Typically, the data base is provided through a Logical Support Analysis (LSA). Unfortunately there are no standards governing the nature and content of this data base.

It seems advisable to place some standards or requirements on the content and nature of the data base. This can be accomplished by carefully examining the project-generated ISD analysis material and structuring the LSA format so that the required data is provided. For example, from the project-generated material, it makes good sense for the LSA to contain:

1. Task title/task title description.

2. List of sequential task elements (steps/activities).

3. The hardware interface required of each task element (step/activity).

4. The stimulus, responses, and feedback requirements associated with each task element.

5. A list of the tools and support equipment required to perform the task.

6. The skills and knowledge associated with each step/activity, as well as the task as a whole.

7. Basic task and element data; e.g.,

    a. Performance criteria (time and accuracy).

    b. Manhours and accumulative time.

    c. Unusual conditions.

It is quite conceivable that the standardization of the data base might reduce the amount of time it takes to perform the ISD analysis. In addition, a standardized format might reduce the amount of documentation required; i.e., it is possible that the LSA form could be designed such that critical training equipment designs could be recorded right on the LSA form by the ISD analyst.

Instructional Features Scenarios

Although the project-developed materials address the relatively new area of instructional features, it seems reasonable that more can be accomplished in this area. One possible improvement might be the construction of instructional features scenarios. These scenarios would fully describe the instructional feature and provide guidance concerning how the instructional feature is to be (or can be) used by the instructor or the Air Force. It is anticipated that the scenarios would be only two or three pages in length and contain:

1. A complete definition of the instructional feature.

2. A section describing the purpose and intended use of the instructional feature.

a. Who is to use the feature.

b. What needs to be done before the feature is used (preparation and planning).

c. How the feature is made operational.

d. How the feature can be used with other instructional features.

3. A functional description; a step-by-step explanation of how the instructional feature is made operational and/or updated.

4. A description of the concurrent events; e.g., the status of other instructional features controls, when the instructional feature in question is being employed.

5. A feature diagram, showing the logic behind the design of the feature, as well as how the feature is to be used.

An example of an instructional features scenario is provided in Appendix E. This example appeared in an article published by Pohlmann, Isley, and Caro (1979). The example is for a DEMONSTRATION PREPARATION instructional feature on a flight simulator.

If such instructional features scenarios were developed they could be distributed to ISD analysts, who could use them when designing simulators. If the ISD analysts found reasons for changing the scenario in a specific situation such modifications could be made. It also seems reasonable that such scenarios could be made a part of the procurement specification, thus, providing more information to the equipment manufacturer concerning how the instructional feature is to operate and how it is to be used by the instructor or the student. Such an approach might help to guarantee that equipment manufacturer designs provide features which are not awkward to use or inefficient.

SPO Specification Improvements

The project was originally designed to examine only those engineering requirements which were impacted by training requirements considerations. During the project it became evident that other engineering requirements needed to be considered. For completeness those other engineering requirements were addressed in the model SPO specification. To improve the model SPO specification, the following activities should be performed:

1. More discussions or interviews should be conducted with specific System Program Offices, such as the F-16 program. These discussions would make it possible to expand upon the "lessons learned" section of the Handbook/Appendix attached to the model SPO specification.

   An expansion in the "lessons learned" section would emphasize the communication of corporate history and knowledge, so previous mistakes would not be duplicated. In addition, the results of training-effectiveness and cost-effectiveness evaluation studies of maintenance trainers should be incorporated into the Handbook/Appendix. For example, efforts are currently under way to begin an evaluation of the F-16 SAMTS; the results of such evaluations should be incorporated into the "lessons learned" section of the Handbook/Appendix.

2. The model SPO specification should be carefully reviewed by:

   a. Maintainability experts.

   b. Reliability experts.

   c. Computer hardware experts.

   d. Software development engineers.

   e. ATC personnel.

   Their comments and concerns should be incorporated into the SPO Handbook/Appendix. It should be mentioned, however, that all paragraphs and subparagraphs in the model SPO specification were reviewed by maintenance trainer engineers. The intent of the reviews specified above are only to provide more detailed input.

3. The Handbook/Appendix should be designed in a sectional manner; i.e., each major paragraph should be independent so so that updates can be easily made. For example, as lessons learned are acquired they should be easily incorporated into the Handbook/Appendix.

4. MIL-STD-1379B should be carefully reviewed to expand the Handbook/Appendix section concerning Data Item Descriptions (DIDs) for maintenance trainers. Currently, a list of potential DIDs is provided, but MIL-STD-1379B might make it possible to expand the list.

5. A warranty paragraph or subparagraph should be added to the model SPO specification.

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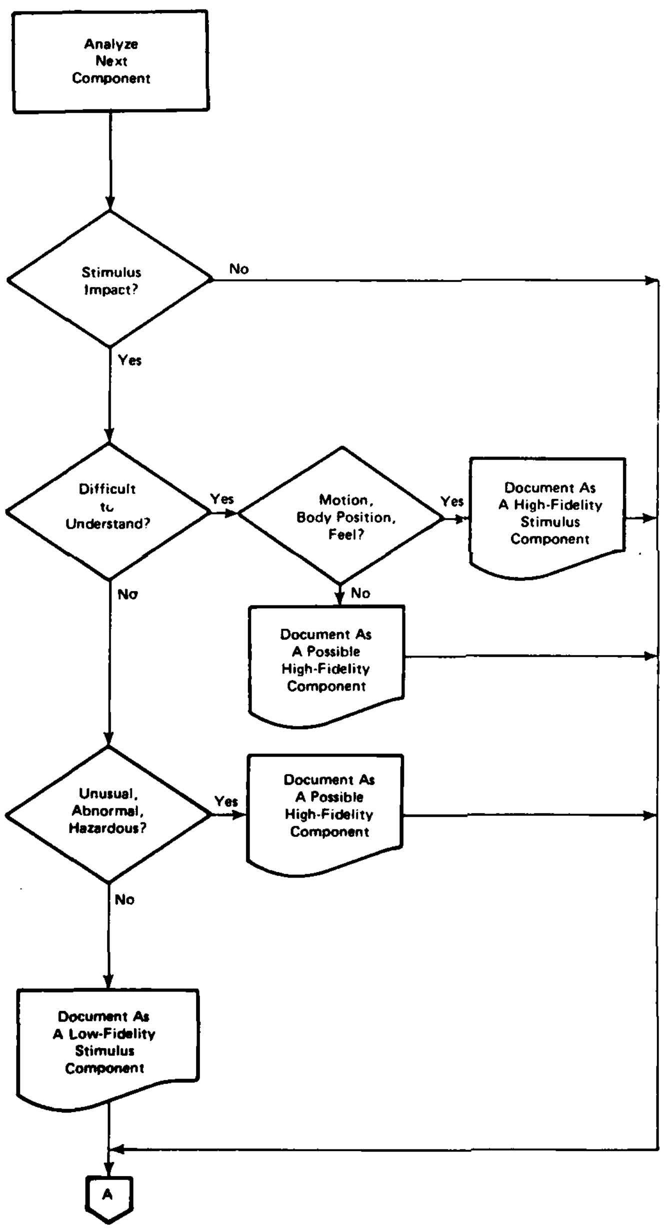
APPENDIX A

FIDELITY DECISION PROCEDURES

COMPONENT FIDELITY FLOW CHART
STIMULUS FEATURES

DECISION LOGIC | **EXPLANATION**



You are asking whether cues from the component directly impact upon the AFSC as part of the task.

If the stimulus can be any value along a continuous scale and/or is difficult to understand, the stimulus is sensed as motion by the position of the AFSC's hand, arm, etc., or is a stimulus that involves feel, it will need to be represented as a high-fidelity stimulus.

Is there some aspect of the stimulus that is extremely unusual, hard to comprehend, potentially dangerous, etc., that suggests that the learner should have practice with a high-fidelity representation during training? (This will have to be noted in Column 12, Form 1).

Go to Page 2, where the components' ability to provide Hi-Fi response opportunities will be determined.

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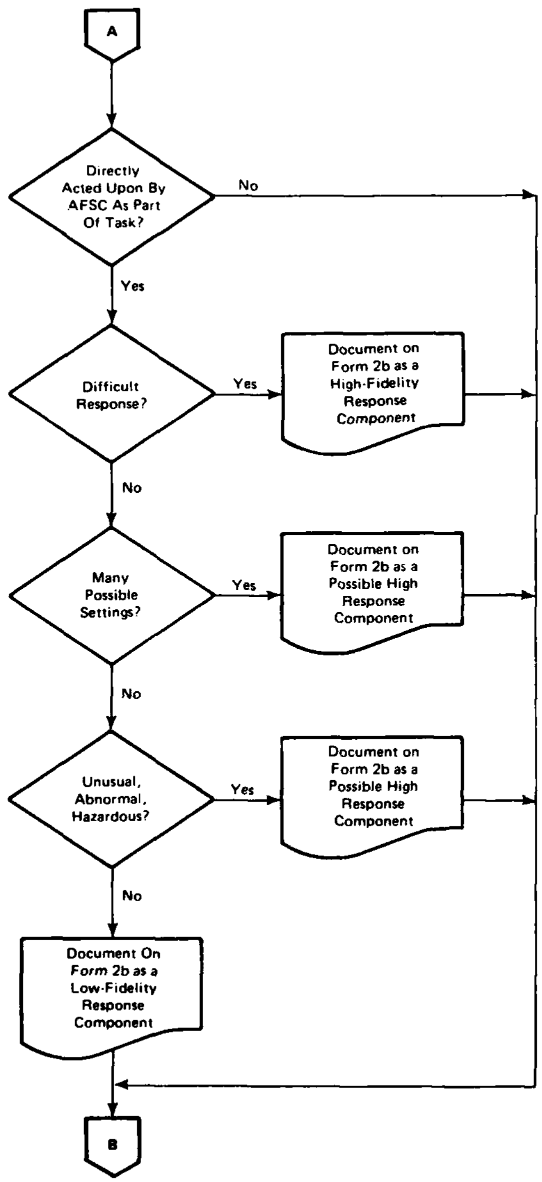
COMPONENT FIDELITY FLOW CHART
RESPONSE FEATURES

DECISION LOGIC	EXPLANATION



You are entering with a component whose stimulus properties you have just analyzed.

You are essentially asking whether the AFSC lays hands (or tools) on this component.

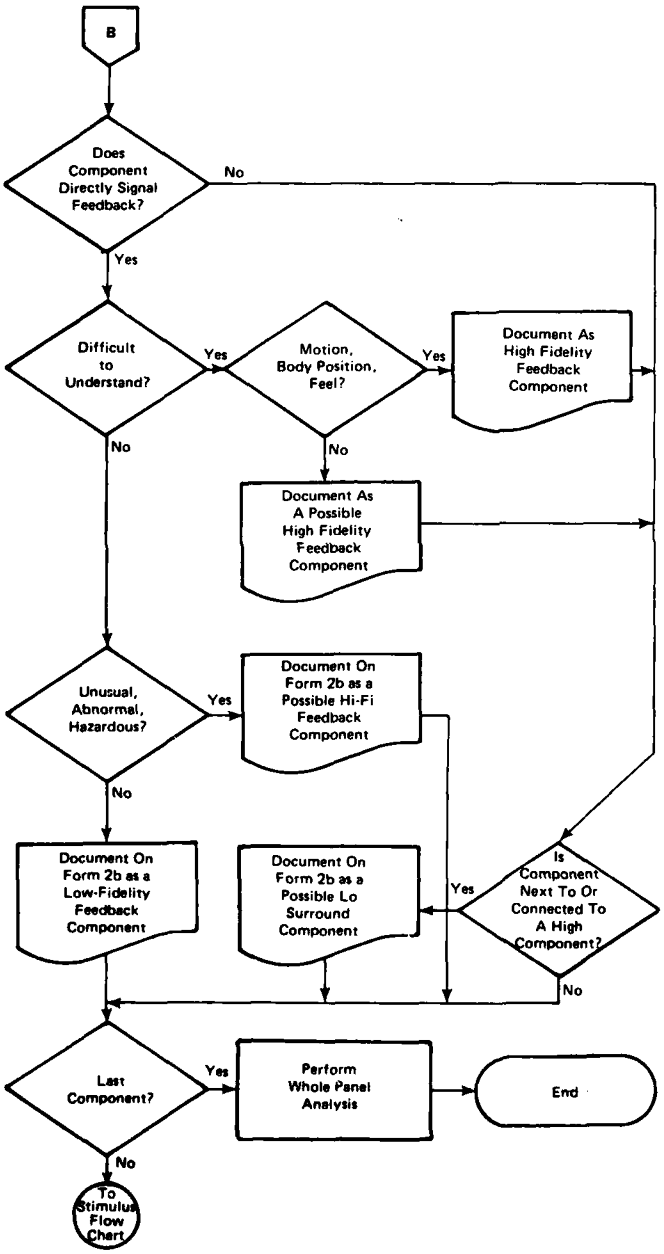
Does the response have to be made in such a way that unaided judgment must be used to determine its adequacy?

Is there the possibility that the component could be located, adjusted, or set at many different locations or values?

Is there some action in relation to this component that is extremely unusual, hard to carry out, potentially dangerous, etc., that suggests that the learner should have practice with a high-fidelity representation of the component during training? (This will have been noted in Column 12, Form 1).

COMPONENT FIDELITY FLOW CHART
FEEDBACK FEATURES

DECISION LOGIC	EXPLANATION



You are entering with a component whose stimulus and response you have just analyzed.

You are asking whether cues from the component signaling the system's response to the AFSC actions impact directly upon the AFSC.

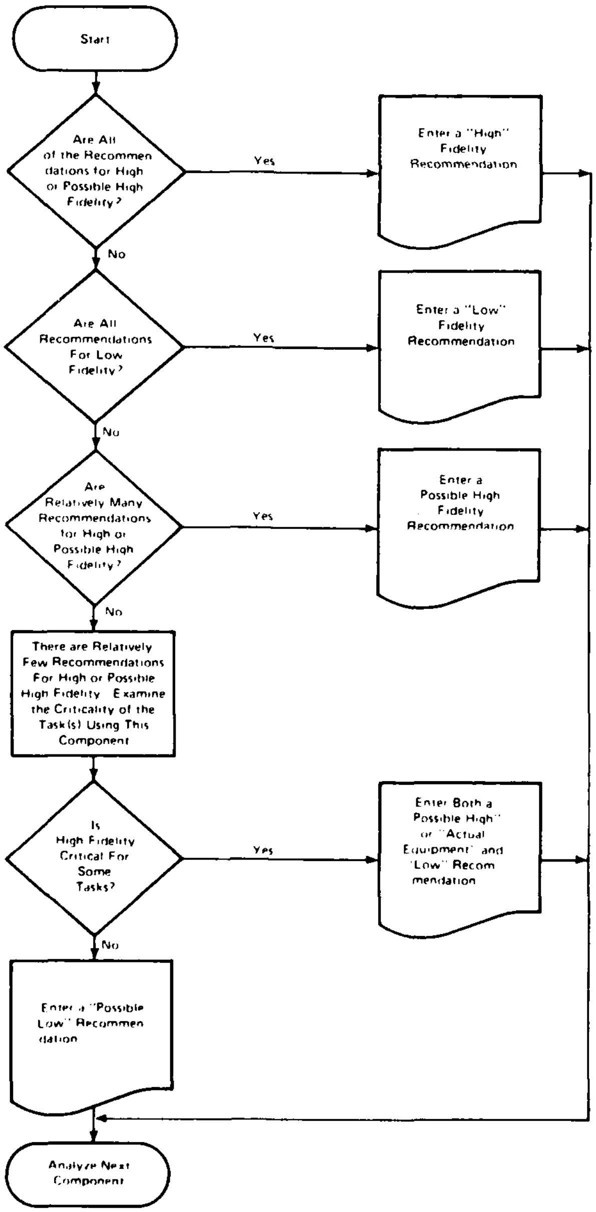
Same as on the Stimulus Features Flowchart.

Same as unusual, abnormal, hazardous stimulus.

Should whole panels be represented on the trainer?

FIDELITY DECISION FLOW CHART

DECISION LOGIC



EXPLANATION

Remember to enter the number of High, Possible High, and Low Fidelity recommendations in Row 12 of Form 2b.

If all or almost all of the recommendations are for High Fidelity, *the final recommendation should be* "High Fidelity."

If all of the recommendations are for Low Fidelity, then the component should, without question, be Low Fidelity.

If more than half of the recommendations are for High Fidelity, then it seems quite likely that the component should be High Fidelity. However, some judgement is required here. Re-examine why you recommended High or Possible High Fidelity. If, in light of the entire set of fidelity recommendations, you think High Fidelity is needed, recommend it. If not, reserve judgement by entering "Possible High."

If there have been only one or two High Fidelity recommendations, you may want to represent the component in two different ways, a High Fidelity when it is needed, but in Low Fidelity in all other cases.

1. COURSE NO.		2. ANALYST			3. DATE	4. PAGE OF
4. COMPONENT NO.	5. COMPONENT NAME	6. FIDELITY	7. RELEVANT TASKS	8. TRAINER USED ON	9. SPECIFIC CHARACTERISTICS THAT THE COMPONENT MUST HAVE	

FORM 3a

APPENDIX B

INSTRUCTIONAL FEATURES

DEFINITIONS

Instructional Features

Are devices or mechanisms on the trainer which control critical aspects of the learning environment, such as presentation of the stimuli, recording and scoring of responses, presentation of augmented feedback messages, and selection of the next activity the student is to be engaged in. The following are instructional features:

a. On-Off/Select Sensing. A control on the trainer which allows the instructor to turn on or off the devices or mechanisms which sense the student's response(s) or to select only those responses which are to be sensed for a given student exercise. A response that is sensed by the trainer is not necessarily recorded by the trainer.

b. On-Off/Select Recording. A control on the trainer which allows the instructor to turn on or off the devices or mechanisms which record the response(s), or to select only those student responses which are to be recorded for a given exercise. A response that is recorded by the trainer is not necessarily scored by the trainer. All responses recorded by the trainer, however, must be sensed by the trainer.

c. On-Off/Select Scoring. A control on the trainer which allows the instructor to turn on or off the devices or mechanisms which score the recorded responses or to select only those recorded responses to be scored for a given exercise.

d. On-Off/Select/Reporting. A control on the trainer which allows the instructor to turn on or off the devices or mechanisms which report student response(s) or score(s), or allows the instructor to select what response(s) or score(s) are to be reported.

e. On-Off/Select Monitoring. A control on the trainer which allows the instructor to turn on or off the devices or mechanisms which monitor the status of the controls and/or displays of the system or subsystem being simulated, or to select which controls and/or displays are to be monitored for a given exercise. All system displays and/or controls, which are monitored by the trainer, are sensed, recorded, and reported by the trainer.

f. Reporting Devices. A device used to report student responses and/or scores and/or the status of the system being simulated. Reporting devices are only used if the trainer is reporting responses, scores, or the system status to the instructor. Reporting devices as used in this specification are either computer controlled printers or CRT (video) screens.

g. Storage Devices. A device used to store student responses, scores, or the status of the system being simulated for future retrieval (e.g., diagnostic purposes or for planning future next activities for the student). Storage devices, as used in this specification are either hardcopy (e.g., printouts which are filed in a convenient manner) or electronic devices (e.g., diskettes, magnetic tape, hard disks, etc.).

h. Adjustable Criteria Control. A control on the trainer which allows the instructor to adjust (change or modify) the value that student responses are compared to during scoring. This control is only appropriate if the trainer is automatically scoring student responses.

i. On-Off/Select Feedback Control. A control on the trainer which allows the instructor to turn on or off the devices or mechanisms that provide the student with augmented feedback messages, or to select the time or schedule of the augmented feedback message given to the student during a given exercise.

j. Feedback Message Adjust. A control or device which allows the instructor to adjust (change or modify) the augmented feedback message that is given to the student during a given exercise.

k. Rate Adjust Control. A control on the trainer which allows the instructor to adjust (change or modify) the rate at which stimuli are presented to the student during a given exercise.

l. Signal-to-Noise Adjust. A control on the trainer which allows the instructor to adjust (change or modify) the ratio of signal-to-noise for a given exercise.

m. Cue Enhancement Control. A control on the trainer which allows the instructor to highlight (magnify, intensify, or otherwise make more noticeable) a stimulus or response for a given exercise. The control can be an on-off control,

where all stimuli or responses are highlighted, or a select control, where the instructor can select which stimulus or response is to be highlighted for a given exercise.

n. Malfunction Insertion. A control on the trainer which allows the instructor to select a malfunction which has been pre-programmed into the trainer.

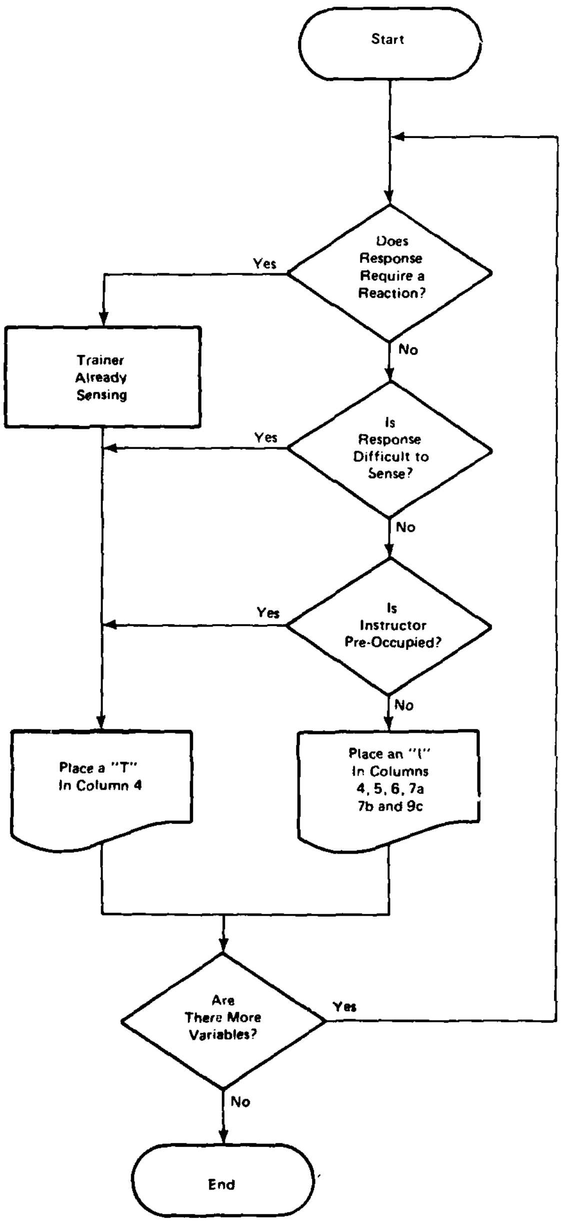
o. System Parameter Control. A control on the trainer which allows the instructor to pre-set (before the exercise begins) a system parameter value or allows the instructor the input system parameter values during the exercise. The control can be used to make operational a malfunction condition, providing the system parameter being altered signifies a malfunction condition.

p. On-Off/Select Next Activity. A control on the trainer whic allows the instructor to turn on or off the next activity pre-programmed for the student, or allows the instructor to select the next activity from a list of pre-programmed next activities.

q. On-Off Freeze. A control on the trainer which allows the instructor to turn on or off the pre-programmed freeze instructions within the trainer, or to freeze the trainer in a given state when a freeze is not pre-programmed. A freeze shall cause all displays, controls, indicators, etc. to remain fixed in their position at the moment of the freeze.

WHO SENSES THE RESPONSES?
COLUMN 4 OF INSTRUCTIONAL FEATURES WORKSHEET

DECISION LOGIC



EXPLANATION

This decision logic must be used for each variable involved in the measure. If two variables are needed such as time and accuracy, then you will go through the flow chart twice. If you are concerned about the accuracy of a sequence (a series of responses) treat each response separately.

"Does the student response to be measured result in a reaction from the trainer?" That is, if the response is to set or adjust the control, does the setting require a specific reaction that is used later? To check this, refer to your fidelity feedback decision on Form 3. If you are dealing with a sequence of responses, go through for each response. If in the sequence the answer is more frequently yes to this question, have trainer sense all responses, otherwise have the instructor sense.

"Is the response difficult to sense by observation?" Would it be difficult to see the student make the response? Does the response occur rapidly? If a measure is a time, does the time measure have to be extremely precise and accurate?

Is the instructor doing something else so that he cannot sense the response? If yes, you need not look at the flow charts for Columns 5, 6, 7 and 10. Go to the flow chart for Column 8 after going through this flow chart for all other variables.

RECALLING PROCEDURES

DEFINITION: Involves having the student recall procedures; e.g., recall equipment assembly and disassembly procedures, recall operation or check out procedures.

PRACTICE SITUATION: The concern is to have the student recall, but not actually perform the steps or procedures. The practice situation should provide the student with an opportunity to chain steps or events in the procedures. A cue should be provided for each step as well as for chaining the steps. Cues are withdrawn as learning continues.

STIMULUS CONSIDERATIONS:

1. Provide highlighting of the cues for each step.

2. Provide highlighting of the cues used to chain the steps.

3. Later in training begin to reduce the level of aiding (i.e., high, medium, low cue enhancement control).

4. Optional. Instead of highlighting the cues the responses can be highlighted. Reduce the level of response enhancement as training continues.

5. If time is a critical factor in measuring, you will need control of the rate of cue presentation.

RESPONSE CONSIDERATIONS:

1. To measure or record the response the student must make an overt response.

2. What to measure? Can measure or record the response, the accuracy of the response (e.g., are the steps performed or recalled in the proper sequence), or the speed of the response.

3. What criterion level? The student should practice until he has reached a stabilized final criterion level.

AUGMENTED FEEDBACK CONSIDERATIONS: Feedback considerations and conditions depend upon the stage of training.

EARLY STAGE:

1. Usually concerned about the accuracy of the response.

2. Feedback should be given immediately after the student's response on step recalled. As training progresses feedback should be delayed; e.g., after every two steps, after three steps, etc.

3. Feedback Message. The purpose of the feedback is error identification. Provide the student with the correct recall sequence. Also provide him with information concerning why the sequence must be maintained. If possible point out the consequence of the incorrect response.

LATE STAGE:

1. Usually concerned about time or about recalling the steps or procedures under unusual situations or conditions, e.g., introducing malfunctions.

2. Feedback should be delayed; i.e., provide feedback after every four or five steps or after the entire procedure has been recalled. Eventually reduce feedback to the operational setting if time is the critical factor, then provide the student with his time, plus the criterion time.

3. Feedback Message. The purpose of the feedback is error identification. Provide the student with the correct recall sequence. Provide the student with information concerning the consequences of the error.

NEXT ACTIVITY: After the feedback message is provided the following activities are appropriate:

EARLY STAGE:

1. If it is the first occurrence of the error, provide the feedback message and resume the problem. The problem may be started from the beginning to facilitate the chaining of the step. Time considerations may require restarting from an intermediate point. In any case, the step immediately preceding the error should be repeated.

Recalling Procedures (Continued)

2. If the student repeatedly commits the same error, then remedial instruction is appropriate.

LATE STAGE:

1. If it is the first occurrence of the error, provide feedback message but do not provide the corrective action. Give the student the opportunity to correct the error and continue the problem or exercise. Make sure the consequence of the error is noted.

2. If the student continually makes the same error, remedial instruction is appropriate, e.g., rehearsal of the procedure from the beginning.

3. Optional. You may elect to freeze the system after two procedural errors are noted. After the freeze, remedial instruction or continuation of same problem is appropriate.

4. If time is the critical factor, have the student practice until criterion time is reached, i.e., repeat the same problem exercise.

OTHER CONSIDERATIONS:

1. Provide the student with a checklist or other mediators to aid in the recalling behavior.

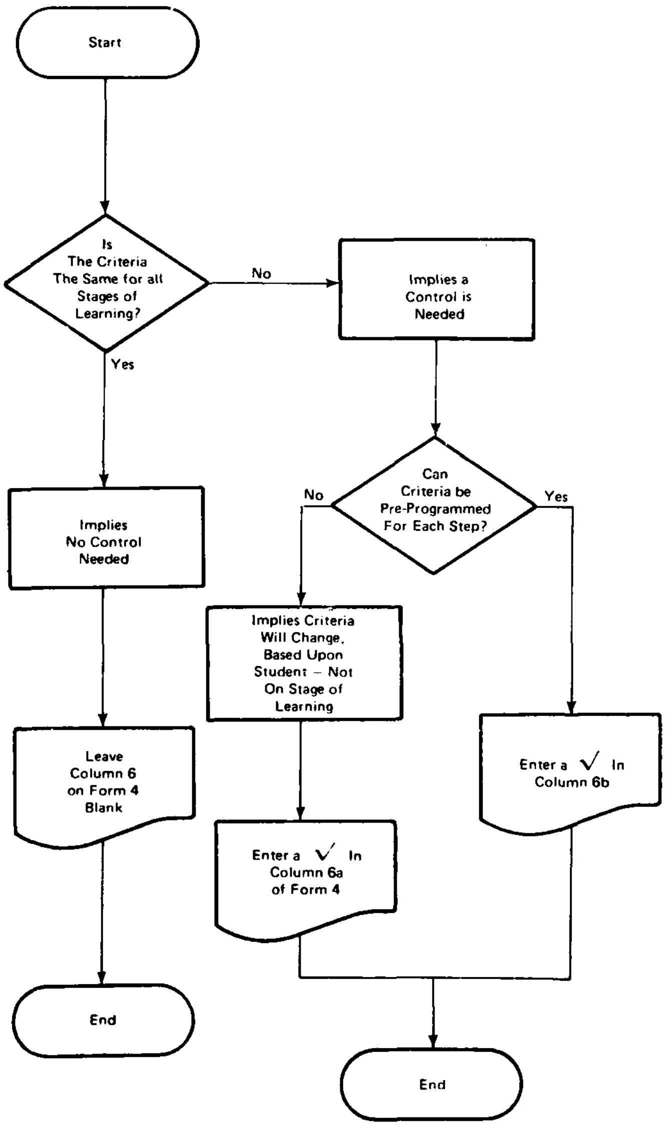
2. Provide the student with practice in associating the mnenomic with the procedural step.

3. Before practice in recalling, it is helpful for the student to see a demonstration.

4. Provide refresher training throughout the course, except where procedures are actually rehearsed or carried out later in the course. Provide practice with novel variations in content and form of the basic material to be recalled.

CRITERIA ADJUST CONTROL

DECISION LOGIC	EXPLANATION



Assumes trainer is scoring student responses; i.e., there is a "T" in Column 6 of the Instructional Features Worksheet.

Review the learning principles. Determine if the same criteria is involved at each stage of learning. Typically the criteria of performance will be different at each stage. This is particularly true if shaping will be involved.

Criteria level can be pre-programmed. If criteria level is likely to change over the life cycle of the trainer, go back and answer "No" to the first question.

If each stage has its own criteria level, then pre-programming is possible. If shaping of behavior is involved, answer "No."

If criteria is to change and cannot be pre-programmed, then a device is needed to enter the specific criteria level.

APPENDIX C

MODEL ISD SPECIFICATION

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5.2 INSTRUCTIONAL CAPABILITIES.

Accomplishment of the training objectives specified in subparagraph 2.5 of this specification requires that the maintenance trainer have several instructional capabilities. The maintenance trainer shall be provided with an instructional system which monitors, controls, evaluates, and provides instructor/student augmented feedback as specified in Table 5.0 and as clarified in the subparagraphs below. (Insert Table 5.0.)

5.2.1 FREEZE CAPABILITY. (Yes ___ No ___.)

a. The maintenance trainer shall freeze under the following conditions:

____
____
____
____
____
____

b. The freeze shall cause all displays, controls, indicators, etc. to remain fixed in their position at the moment of the freeze.

c. The freeze shall be activated by:

____
____
____
____
____
____

d. When unfrozen (deactivated) the maintenance trainer shall:

____
____
____
____
____
____

5.2.2 MALFUNCTION SELECTION. (Yes ___ No ___.)

a. Simulated malfunctions shall be selected in the following manner:

____
____
____
____

b. Once selected a malfunction's effects shall remain in effect until:

____
____
____

c. The maintenance trainer shall be designed to permit the creation of future malfunctions specified in subparagraphs 3.2.1.3 of this specification.

5.2.3 SIGN-IN CAPABILITY. (Yes ___ No ___.)

a. During sign-in the trainer shall request the following information:

____
____
____

b. Sign-in information entry shall be the responsibility of:

____
____
____

5.2.4 NUMBER OF RESPONSES. (Yes ___ No ___.)

There shall be _____ number of responses per student. All responses shall be stored for _____ weeks.

5.2.5 MONITORING INSTRUCTIONAL FEATURES. (Yes ___ No ___.)

a. The following variables and/or responses shall be sensed/recorded by the trainer: ______________________________
____

b. The following system values shall be monitored by the trainer:

____
____

c. The following criteria shall be pre-programmed and/or entered or adjusted by the instructor: ______________________________

____

5.2.6 AUGMENTED FEEDBACK INSTRUCTIONAL FEATURES. (Yes ___ No ___.)

a. The following augmented information shall be provided in the feedback message presented by the trainer:

____

____

_________________________ _________________________

b. The feedback schedule fo   objective/exercise shall be as follows:

____

____

____

____

____

____

5.2.7 NEXT ACTIVITY FEATURES. (Yes ___ No ___.)

After an objective/exercise has been completed by the student the next activity introduced to the student shall be as follows.

____

____

____

____

____

____

5.2.8 STIMULUS INSTRUCTIONAL FEATURES. (Yes ___ No ___.)

a. The trainer shall present the stimuli for the objectives/exercises specified below at the rates specified below:

____

____

____

____

____

____

b. The trainer shall present the stimuli for the objectives/exercises below with the ratio of signal-to-noise specified below:

____
____
____
____
____
____

5.2.9 CUE ENHANCEMENT FEATURES. (Yes ___ No ___.)

The following cues shall be enhanced during the following objectives/exercises:

____
____
____
____
____
____

5.3 STUDENT STATION(S). (Yes ___ No ___.)

5.3.1 STUDENT STATION, NUMBER AND KIND.

a. There shall be ____ kinds of student station(s).

b. There shall be _____ of kind one, ____ of kind two.

5.3.2 STUDENT STATION: DISPLAYS, CONTROL, AND INSTRUCTIONAL EQUIPMENT.

In addition to the displays, controls, indicators, and parts specified in subparagraph 4.2.2 herein, the student station shall contain the following:

____
____
____
____
____
____

This subparagraph describes those displays, controls, indicators, LRUs, SRUs, and parts which can be off-the-shelf and as such do not need to be simulated or modified. Such a list is contained in the specification to assure that the vendor knows that the specified off-the-shelf equipment must be included and interfaced with the controls, display, etc. that are to be simulated.

Parameters: Enter list of off-the-shelf equipment to be included or used on the trainer. FORM 3a can be used as a source. If any part, SRU, LRU, etc., indicated on FORM 3a must appear exactly as the actual equipment and function as the actual equipment consider using an off-the-shelf item. Any item listed in subparagraph 4.2.2 must not appear in this subparagraph.

Lessons Learned: The procedures specified in the ISD Handbook provide a means for indicating the degree of fidelity required of each simulated item. In most cases, only certain aspects of the item are critical to the learning process and the whole item need not be physically and functionally like the actual equipment. However, there may be times when either the actual item must be used or it is more economical to use the actual item. This subparagraph is reversed for these occasions. You should also consider the cost associated with using a standard off-the-shelf item. Often, because of the trainer design, it becomes difficult (and expensive) to interface actual items with the trainer.

5.0 INSTRUCTIONAL FEATURES.

Rationale and Guidance: This is only a header paragraph used to identify the Instructional Features section of the model.

Parameters: No blanks to be completed by the ISD analyst.

Lessons Learned: None.

5.1 INSTRUCTIONAL FEATURES, DESCRIPTION.

Rationale and Guidance: This subparagraph explains the contents of the subparagraphs within the major paragraph.

Parameters: No blanks to be completed by the ISD analyst.

Lessons Learned: None.

5.2 INSTRUCTIONAL CAPABILITIES.

Rationale and Guidance: This subparagraph contains the instructional features and/or capabilities the trainer must have to facilitate attainment of the specified objectives. It should be pointed out that each objective might require a different set of instructional capabilities; i.e., instructional features and/or capabilites are training objective specific. Thus it is important to identify which objectives require which capabilities. This identification and determination is made following the procedures in the Handbook of ISD Procedures for Design and Documentation.

Instructional features are those features on the trainer which control certain aspects of the learning environment; the presentation of the stimulus, the monitoring of student responses, the provision of augmented feedback to the student concerning the correctness of his response, and the selection of the next activity the student is directed to. The Handbook of ISD Procedures for Design and Documentation makes a determination of 17 possible instructional features. Those instructional features which are required are to be listed in this subparagraph and are further clarified in the subparagraphs which follow.

Parameters: Enter the instructional features required to complete each specific training objective or insert FORM 4 and the Instructional Feature Worksheet as Table 5.0 and Table 5.1, respectively).

Lessons Learned: Instructional features are a new area and not much has been learned about their specifications.

5.2.1 FREEZE CAPABILITY.

Rationale and Guidance: If a freeze capability is indicated, it needs to be further described in this section. If no freeze capability is required, enter a check beside "No" in the space provided.

In this subparagraph you are to describe:

- when the trainer shall freeze.
- how the freeze shall be deactivated.
- what the trainer shall do when the controls/dispalys are unfrozen.

This information can be recorded on FORM 4 (Table 5.0 of the model) instead of in a separate subparagraph.

Parameters: There are three blanks to be completed by the ISD analyst.

a. "The maintenance trainer shall freeze under the following conditions: ______________________________."

Enter the conditions that must exist to cause the trainer to freeze. These conditions might be different for each training objective, if this is the case, associate each condition with a particular objective. Possible conditions are:

- on the __________ procedural error; (e.g., the trainer shall freeze when the third procedural error is committed by the student).

- when a dangerous situation is created by the student's actions; dangerous is defined as a situation which might cause harm to the student or harm to the equipment.

- or on demand of the instructor (i.e., the freeze is not pre-programmed).

b. No entry to be made by the ISD analyst.

c. "The freeze shall be deactiviated by __________________."

Enter how the freeze shall be deactivated. Possible activation strategies are:

- a control located on the instructor station.

- by the correction of the error(s) that caused the freeze (if this method is slected, provisions must be made for identifying which errors must be corrected; e.g., errors to be corrected are displayed on the CRT at the time of the freeze).

d. "When unfrozen (deactivated) the maintenance trainer shall ___ __________________."

Enter what occurs after deactivation of the freeze. Possible options are:

- to have the problem or exercise start from the beginning.

- to have the problem or exercise continue as if the error was not committed and the freeze did not occur.

- to have the trainer back-up to the error (first error) and have the student continue from there.

Also consider the possibility of displaying the errors on a CRT or a printer along with the correction procedure. If possible communicate to the student why the error was critical.

Lessons Learned: Not much information has been gathered about the freeze feature.

5.2.2 MALFUNCTION SELECTION.

Rationale and Guidance: This subparagraph shall only be included if malfunctions are to be identified and/or corrected by the students. If malfunctions are not to be identified and/or corrected place a check beside "No" in the space provided.

Parameters: There are two blanks to be completed by the ISD analyst.

a. "Simulated malfunctions shall be selected in the following manner: ______________________."

Enter how the malfunctions for a particular exercise are to be selected. Malfunctions can be selected in three different ways.

- mechanically - e.g., by having the instructor activate certain switches or mechanical devices or by having the instructor insert defective LRUs, SRUs, parts, or components.

- electronically - e.g., pre-programmed (if the trainer is computer driven). In this case a malfunction menu can appear on a CRT and be selected by the instructor either using a light/sonic pencil or by entering a menu number on a keyboard.

- electronically - e.g., by having the instructor insert special parameter values which would create a given malfunction (insertion of values must be made via a keyboard).

FORM 4 specifies if the malfunction is to be pre-programmed or if parameter values are to be set If not all malfunctions are to be selected/created the same way then specify how each is to be selected or created. Consider specifying this in table form.

MALFUNCTION	SELECTION METHOD

If the selection method is through a parameter set control, specify which parameters and values need to be set to select/create the specific malfunctions; i.e., specify the parameter and the value that parameter must have to create a specific malfunction.

b. "Once selected a malfunction's effect shall remain in effect until ______________________________."

Enter when a malfunction's effect is cancelled, usually two methods are used.

- a malfunction's effect is cancelled when the student performs the proper corrective action or has correctly identified the correct malfunction.

- a malfunction's effect can be cancelled by the instructor using a control on the instructor station. Activation of the control returns the equipment to a normal state.

Lessons Learned: None.

5.2.3 SIGN-IN CAPABILITY.

Rationale and Guidance: This subparagraph should only be completed if a sign-in is required (i.e., indicated on FORM 4). If a sign-in is required then the vendor will need to know what information is to be requested during the sign-in activities.

Parameters: Enter the information the trainer should request during the sign-in activity. Consider the following:

- student's name (or team name).
- student's ID number (or team ID number).
- exercise number or designation.

- training objective number.
- level of training (AFSC).
- level of Cue Enhancement.

Also indicate who shall have responsibility for providing the sign-in information (the student or the instructor).

Lessons Learned: None.

5.2.4 NUMBER OF RESPONSES.

Rationale and Guidance: This subparagraph should only be completed if a storage device is required. If a storage device is required some estimate of the capacity of the storage device needs to be given. This is difficult to determine, but it would be helpful in determining the capacity of the storage device if the engineer knew how many responses per student need to be stored, as well as the length of time they need to be stored.

Parameters: Enter the number of responses per student which must be stored and enter how long the responses must be stored in weeks. This information will help the Acquistion Manager to determine the capacity of the needed storage device.

Lessons Learned: This is a new requirement.

5.2.5 MONITORING INSTRUCTIONAL FEATURES.

Rationale and Guidance: Each training objective/exercise presented by the trainer requires that certain student responses be sensed, recorded, scored, and/or reported. It is essential to communicate to the vendor what responses and variables are sensed, recorded, scored, and reported by the trainer. It is also important for the vendor to know what system parameters are to be monitored.

Parameters: There are three blanks to be completed by the ISD analyst.

a. "The following variables and/or responses shall be senses/recorded/scored/reported by the trainer ____________."

   Enter for each objective the variables or responses the trainer must keep track of. The information can be presented in table form.

OBJECTIVE NUMBER	VARIABLE	DEGREE			
		SENSED	RECORDED	SCORED	REPORTED

This information can be obtained directly from the Instructional Features Worksheet. You should list here only those variables/responses that the trainer has responsibility for (i.e., has a "T" entered in the appropriate columns of the Instructional Features Worksheet). You need only enter the highest responsibility of sensed, recorded, scored, or reported (these terms are defined in the ISD Handbook).

b. "The following system values shall be monitored by the trainer ____________________."

Enter the system values to be monitored per objective or exercise (e.g., the reading on display XYZ). Only include those objective/exercises where the trainer has the responsibility to monitor the simulated system. This information can be presented in table form.

OBJECTIVE NUMBER	SYSTEM VALUE

This information can be obtained directly from the Instructional Features Worksheet.

c. "The following criteria shall be pre-programmed and/or entered or adjusted by the instructor: ____________________."

For each objective/exercise enter the criteria the student's performance will be compared against. Only enter the criteria for those objectives/exercises where the trainer will have responsibility for scoring the student's performance. Do not include those objectives/exercises where the instructor is given the responsibility for scoring the student's performance. This information can be presented in table form.

OBJECTIVE NUMBER	CRITERIA VALUE	PRE-PROGRAMMED	VARIABLE INPUT/OUTPUT

If an objective requires an adjustable criteria (variable input criteria) specify the possible range of criteria values.

This information is directly obtainable from the Instructional Features Worksheet.

Lessons Learned: This is a new requirement.

5.2.6 AUGMENTED FEEDBACK INSTRUCTIONAL FEATURES.

Rationale and Guidance: This subparagraph should only be completed if feedback is being controlled by the trainer. If this is the case place a check beside "Yes" in the space provided.

Two aspects of augmented feedback need to be clarified; the content of augmented feedback message and the feedback schedule. Since augmented feedback is objective/exercise specific, the content of the message and the schedule must be specified for each objective/exercise.

Parameters: There are two blanks to be completed by the ISD analyst.

a. "The following information shall be provided in the augmented feedback message presented by the trainer: ________________."

Enter the content of the augmented feedback message presented by the trainer. If part of the message is provided by the instructor indicate which part. Also indicate if the instructor needs the capability to adjust the augmented feedback message. This information is directly obtainable from the Instructional Features Worksheet and FORM 4. The required information can be presented in table form.

OBJECTIVE NUMBER	CONTENT			ADJUST CAPABILITY	PRE-PROGRAMMED
	INCORRECT RESPONSE	SCORE	REASON		

b. "The feedback schedule for each objective/exercise shall be the following: ______________________________."

Enter the feedback schedule for each objective/exercise where augmented feedback is controlled by the trainer. The feedback schedule can either be immediate or delayed. Also specify if the schedule is to be pre-programmed or set by the instructor before the objective/exercise begins. This information is obtainable from the Instructional Features Worksheet and FORM 4 and can be presented in table form.

OBJECTIVE NUMBER	SCHEDULE		PRE-PROGRAMMED	ADJUSTABLE
	IMMEDIATE	DELAYED		

Lessons Learned: This is a new requirement.

5.2.7 NEXT ACTIVITY FEATURES.

Rationale and Guidance: This subparagraph should only be completed if the next activity is controlled by the trainer. If the next activity is controlled by the trainer for any objective/exercise place a check beside the "Yes" in the space provided.

If the next activity is controlled by the trainer then the vendor will need to know what the next activity is to be. In addition the vendor will need to know if the instructor wants the capability to alter the next acitivity if it is pre-programmed or to select the next activity from a menu of possible next activities.

Parameters: For each objective/exercise enter the next activity to be introduced to the student. Also indicate if the next activity is pre-programmed and if the instructor wants the capability to

than one possible next activity then allow the instructor to select the next activity from a menu. This information is obtainable from the Instructional Features Worksheet and FORM 4. This information can be presented in table form.

OBJECTIVE NUMBER	NEXT ACTIVITY (ACTIVITIES)	PRE-PROGRAMMED		MENU
		NO CHANGE	FUTURE CHANGE	

Lessons Learned: This is a new requirement.

5.2.8 STIMULUS INSTRUCTIONAL FEATURES.

Rationale and Guidance: This subparagraph should only be completed if the trainer is controlling either or both the rate of stimulus presentation and the ratio of signal-to-noise. If the trainer is controlling these aspects of the learning environment place a check beside "Yes" in the space provided.

If the trainer is controlling the rate of stimulus presentation, the vendor must be informed of the rate(s) you intend to have the stimulus presented. The rate(s) may vary from objective/exercise to objective/exercise; thus they must be specified for each objective/exercise.

If the trainer is controlling the signal-to-noise ratio then the vendor must be informed of the ratio(s) you desire for each objective/exercise.

Parameters:

a. "The trainer shall present the stimuli for the objective/exercises specified below at the rates specified below: ______________ ____________________________."

Enter, for each objective where the trainer has control over the rate, the rate of stimulus presentation; e.g., 2 stimuli/minute. If the rate is to be entered by the instructor, instead of pre-programmed, indicate the possible range of rates. This information can be presented in table form.

OBJECTIVE NUMBER	PRE-PROGRAMMED RATE	VARIABLE RATE RANGE

b. "The trainer shall present the stimulus for each objective/exercise below with the ratio of signal-to-noise specified below: ________________________."

Enter the ratio of signal-to-noise for each objective/exercise where the trainer has control of the ratio of signal-to-noise. This can be entered as a specific ratio if known (e.g., 10-to-1) or as an intensity (e.g., high signal-to-low noise). Also specify if the ratio is pre-programmed or if it is to be entered by the instructor before the objective/exercise is presented to the student. This information can be presented in table form.

OBJECTIVE NUMBER	PRE-PROGRAMMED RATIO(S)	VARIABLE RATIO RANGE

Lessons Learned: This is a new requirement.

5.2.9 CUE ENHANCEMENT FEATURES.

Rationale and Guidance: This subparagraph should only be completed if cue enhancement is going to be provided by the trainer; if it is, place a check beside the "Yes" in the space provided.

If cue enhancement is going to be provided by the trainer, the vendor must know which objectives/exercises require cue enhancement as well as what cues are to be enhanced.

Parameters: Enter a list of the objectives that require cue-enhancement and enter the cues which are to be enhanced. Also specify if the enhancement of a particular cue is pre-programmed or to be entered by the instructor. This information can be presented in table form.

OBJECTIVE NUMBER	CUE TO ENHANCE	PRE-PROGRAMMED	VARIABLE INPUT

Lessons Learned: This is a new requirement.

5.3 STUDENT STATION(S).

Rationale and Guidance: This subparagraph should only be completed if there is going to be a student station. Most trainers have a student station and an instructor station. However there is a trend to combine the student station and instructor station into one station, from which both the instructor and student conduct and participate in the training. It is not the intent of this paragraph to force a particutar configuration on the ISD analyst. If the analyst decides to have only one station, then paragraph 5.3 should be relabeled "STATION(S)" and subparagraph 5.3.1, subparagraph 5.3.2, paragraph 5.4, subparagraph 5.4.1, and subparagraph 5.4.2 should be deleted. The relabeled paragraph 5.3 should then describe how the station is to look by listing the controls that are to be located on that station.

Parameters: No blanks to be completed by ISD analyst.

Lessons Learned: None.

5.3.1 STUDENT STATION(S), NUMBER AND KIND.

Rationale and Guidance: The purpose of this subparagraph is to inform the vendor of the different kinds of student stations that are required as well as the number of each kind that is required.

Most maintenance trainers have only one type or kind of student station. However there may be instances when more than on kind is required, e.g., when teams are required to complete a given task each team member might have a different kind of student station.

Parameters: There are two blanks to be completed by the ISD analyst.

APPENDIX D

SPO SPECIFICATION

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3.2.5.3 BUILT-IN-TESTS, SELF-TESTS, AND DIAGNOSTIC TESTS. (Yes ___ No ___.)

The maintenance trainer test requirements shall be as follows: ___
____
____.

3.2.6 ENVIRONMENTAL CONDITIONS. (Yes ___ No ___.)

The maintenance trainer, including all the components, shall be designed for operation and storage within the following limits.

a. Operational

(1) Temperature: _____ to ____ degrees C.

(2) Relative Humidity: _____ to _____ percent (non-condensing) at _____°C.

(3) Atmospheric pressure sea-level to _____ meters altitude.

b. Non-Operating

(1) Temperature: _____ to _____°C.

(2) Relative Humidity: _____ to _____ percent (non-condensing) at _____°C.

(3) Atmospheric pressure sea-level to _____ meters altitude.

3.2.6.1 OTHER ENVIRONMENTAL CONDITIONS. (Yes ___ No ___.)

The maintenance trainer shall meet the following additional environmental condition requirements: _________________________.

3.2.7 TRANSPORTABILITY. (Yes ___ No ___.)

a. Design for transportation shall be based on an expected relocation of the trainer on a _______ basis during its life expectancy.

b. The maintenance trainer transportability requirements shall be: ____.

3.2.7.1 DISASSEMBLY FOR SHIPMENT. (Yes ___ No ___.)

____
____

3.2.8 DELIVERY. (Yes ___ No ___.)

The maintenance trainer delivery requirements shall be as follows: ____.

3.2.8.1 INSTALLATION. (Yes ___ No ___.)

The maintenance trainer installation requirements shall be as follows: ______________________________________.

3.3 DESIGN AND CONSTRUCTION.

Major consideration of design and construction shall be performance, safety, availability for training, reliability, maintainability, accessability, and life cycle cost to the Government.

3.3.1 MATERIALS, PARTS, AND PROCESSES. (Yes ___ No ___.)

Materials, parts, and processes shall be selected in accordance with MIL-STD-143, unless otherwise specified herein. However, it is intended that the contractor be permitted maximum freedom in selecting processes, parts, and assemblies to achieve the required quality and performance at minimum life cycle cost. To permit this flexibility and retain adequate quality, the contractor shall: ______________________________________.

3.3.1.1. PARTS CONTROL PROGRAM. (Yes ___ No ___.)

The parts control program shall be: ____________________.

3.3.1.1.1 SELECTION OF PARTS. (Yes ___ No ___.)

In addition to the requirements specified in paragraph 3.3.1.1 of this specification, the following requirements shall apply: ______ ____.

3.3.1.1.1.1 PARTS DOCUMENTATION. (Yes ___ No ___.)

Parts documentation requirements shall be as follows: ________ ____.

3.3.1.1.1.2 PARTS CONTROL EXEMPTIONS. (Yes ___ No ___.)

Items exempt from parts control shall be: ________________ ____.

3.3.1.2 CONDUCTOR IDENTIFICATION. (Yes ___ No ___.)

Conductor identification requirements shall be as follows: _______
____.

3.3.1.3 TERMINAL ENDS. (Yes ___ No ___.)

Terminal ends shall have the following requirements: ____________
____.

3.3.1.4 SPARE CONDUCTORS. (Yes ___ No ___.)

a. Provisions for spares shall be: ______________________________
____.

b. The following shall be exempt from the requirements above:
____.

3.3.1.5 FINISHES AND PROTECTIVE COVERINGS. (Yes ___ No ___.)

The finishes and protective coverings requirements shall be as follows: ____.

3.3.1.6 POWER. (Yes ___ No ___.)

3.3.1.6.1 PRIMARY POWER SOURCES. (Yes ___ No ___.)

The maintenance trainer shall be designed to operate from the following power source(s): ____________________________________.

3.3.1.6.1.1 TOLERANCES. (Yes ___ No ___.)

Unbalanced line currents in the systems shall not exceed _____ percent of the average simultaneously measured line current. The power factor measured at the primary power source of the total inputs shall not be less than _____ percent for any mode of operation. The training device shall be protected from permanent damage, alteration of characteristics, and loss of memory due to total power failure.

3.3.1.6.2 CIRCUIT DESIGN. (Yes ___ No ___.)

____

____

3.3.1.6.3 POWER SUPPLIES. (Yes ___ No ___.)

The maintenance trainer power supply requirements shall be as follows: ____.

3.3.1.6.4 OVERLOAD PROTECTION. (Yes ___ No ___.)

The maintenance trainer overload protection requirements shall be as follows: ____.

3.3.1.6.5 UTILITY POWER. (Yes ___ No ___.)

The utility power requirements shall be as follows: ____________ ____.

3.3.1.6.6 MAIN POWER DISTRIBUTION PANEL. (Yes ___ No ___.)

The main power distribution panel requirements shall be as follows: ____.

3.3.1.6.7 POWER INTERRUPTION AND TRANSIENTS. (Yes ___ No ___.)

a. The maintenance trainer shall be protected from permanent damage and modification of characteristics and loss or change of computer stored memory information resulting from the following nonsimultaneous conditions of power sources: _______ ____.

b. The design of the trainer shall be such that when a power interrupt occurs, which causes an equipment shutdown, the point at which the training was interrupted shall be identified.

3.3.1.6.8 GROUNDING. (Yes ___ No ___.)

The grounding requirements shall be as follows: _______________ ____.

3.3.1.6.9 WIRING, GENERAL. (Yes ___ No ___.)

____

____

3.3.1.6.9.1 WIRING REQUIREMENTS. (Yes ___ No ___.)

The wiring requirements shall be as follows: __________________ ____.

3.3.1.7 MECHANICAL CONNECTORS. (Yes ___ No ___.)

Mechanical connector(s) requirements shall be as follows: ________
____.

3.3.1.8 TIME TOTALIZER(S). (Yes ___ No ___.)

The time totalizer requirements shall be as follows: ____________
____.

3.3.1.9 SCREW AND PIPE THREADS. (Yes ___ No ___.)

Screw and pipe thread requirements shall be as follows: __________
____.

3.3.1.10 THERMAL DESIGN. (Yes ___ No ___.)

Thermal design requirements shall be as follows: ________________
____.

3.3.1.11 FASTENERS. (Yes ____ No ___.)

Fasteners used on the trainer shall meet the following requirements: ____.

3.3.2 ELECTROMAGNETIC COMPATIBILITY. (Yes ___ No ___.)

The maintenance trainer shall have the following electromagnetic compatibility requirements: ______________________________.

3.3.3 NAME PLATES AND PRODUCT MARKING, GENERAL. (Yes ___ No ___.)

a. Unless otherwise specified herein, name plates and product markings shall be: ______________________________________.

b. Control panel markings shall be: ___________________________.

c. Abbreviations used in marking shall be: _____________________
____.

3.3.3.1 NAME PLATES. (Yes ___ No ___.)

Name plates requirements shall be as follows: __________________
____.

3.3.3.2 PARTS IDENTIFICATION. (Yes ___ No ___.)

The parts identification requirements shall be as follows: _______ ____.

3.3.3.3 COVER MARKING. (Yes ___ No ___.)

Cover marking requirements shall be as follows: ______________ ____.

3.3.3.4 PRECAUTIONARY MARKINGS. (Yes ___ No ___.)

The precautionary marking requirements shall be as follows: ______ ____.

3.3.3.5 SAFETY MARKINGS. (Yes ___ No ___.)

The safety marking requirements shall be as follows: ___________ ____.

3.3.3.6 ELECTRICAL POWER MARKINGS. (Yes ___ No ___.)

The electrical power marking requirements shall be as follows: ___ ____.

3.3.3.7 SHIPPING AND STORAGE MARKINGS. (Yes ___ No ___.)

Shipping and storage marking requirements shall be: ____________ ____.

3.3.3.8 OTHER MARKINGS. (Yes ___ No ___.)

____

____

3.3.4 WORKMANSHIP. (Yes ___ No ___.)

The trainer shall meet the workmanship requirements specified below: ______________________________________.

3.3.5 INTERCHANGEABILITY. (Yes ___ No ___.)

The interchangeability requirements shall be as follows: _________ ____.

3.3.6 SAFETY, GENERAL. (Yes ___ No ___.)

a. The design and construction of the maintenance trainer shall consider optimum safety of personnel when installing,

operating, adjusting, maintaining, and moving the maintenance trainer, either during operation or nonoperation. The training device shall conform to the health and safety requirements of Requirement 1 of MIL-STD-454 and MIL-STD-1472, unless otherwise specifed directly below. The procedures described in MIL-STD-882 shall be used to minimize potential hazards and to reduce the possiblity of system degradation and personnel injury, uless otherwise specified directly below.

b. The Military Standards reference above shall apply except as stated below: ____.

3.3.6.1 HAZARDOUS MATERIAL. (Yes ___ No ___.)

a. Materials used in the construction of the maintenance trainer shall not support the propagation of flame; all pyrotechnics (missile squibs, warheads, propellants) shall be inert.

b. Where the generation of toxic or noxious gases cannot be eliminated, the design effort shall be toward the control and minimization of these hazards.

3.3.6.2 FIRE DETECTION. (Yes ___ No ___.)

The fire detection requirements shall be as follows: __________ ____.

3.3.6.2.1 FIRE ALARM. (Yes ___ No ___.)

The fire alarm requirements shall be as follows: _________________ ____.

3.3.6.2.2 FACILITY FIRE CONTROL INTERFACE. (Yes ___ No ___.)

Facility fire control interface requirements shall be as follows: ____.

3.3.6.3 OVERHEAT SENSING. (Yes ___ No ___.)

The overheat sensing requirements shall be as follows: ___________ ____.

3.3.6.4 FIRE STOP SEALING. (Yes ___ No ___.)

____
____

3.3.6.5 EMERGENCY POWER OFF. (Yes ___ No ___.)

a. The emergency power off requirements shall be as follows: ____
____.

b. The emergency power off switch shall: ____________________
____.

3.3.6.6 OTHER SAFETY REQUIREMENTS. (Yes ___ No ___,)

____

____

3.3.6.7 ACOUSTIC NOISE.

3.3.6.7.1 HAZARDOUS NOISE.

a. The sound level and exposure time in all areas where the instructor or student might be shall be held below the values calculated from the following formula:

$$T \stackrel{\wedge}{=} 16 \div 2 \ (L-80)/4$$

where T = Duration of Total Daily Exposure in hours.
L = Noise Level in dBA.

b. The maximum dBA shall be: ______________________________.

3.3.6.7.2 SPEECH INTERFERENCE NOISE LEVEL. (Yes ___ No ___.)

a. The noise level at student and instructor station(s) shall not exceed an articulation index (AI) of 0.7, where the AI is determined by the Octave Band Method.

b. Exception: Where simulated sounds reflecting actual aircraft conditions for the student(s) violate the AI above, the requirements of this paragraph are void for the time period that such simulated sounds are actuated, except that the limits in paragraph 3.3.6.7.1 herein shall not be exceeded.

3.3.6.8 SAFETY DESIGN. (Yes ___ No ___.)

The safety design requirements shall be as follows: ____________
____.

3.3.7 HUMAN PERFORMANCE/HUMAN ENGINEERING.

In order to achieve optimum performance of the instructor, student, and maintenance personnel, and to assure a high degree of man-machine compatibility, the trainer shall: ____________________
____

3.4 DOCUMENTATION. (Yes ___ No ___.)

Documentation shall be provided as specified in this specification and in the Contract Data Requirement Lists.

3.5 LOGISTICS.

3.5.1 MAINTENANCE CONCEPT. (Yes ___ No ___.)

The maintenance concept shall be: ______________________________
____.

3.5.2 SUPPLY. (Yes ___ No ___.)

Selection of parts shall be in accordance with subparagraph 3.3.1.1 and its accompanying subparagraph of this specification.

3.6 PERSONNEL AND TRAINING. (Yes ___ No ___,)

3.6.1 PERSONNEL. (Yes ___ No ___.)

The maintenance trainer shall be designed to be operated and maintained by: ____.

3.6.2 TRAINING. (Yes ___ No ___.)

The training of personnel requirements shall be as follows: ______
____.

3.7 MAJOR COMPONENT CHARACTERISTICS. (Yes ___ No ___.)

Major component characteristics shall be as follows: ____________
____.

4.0 QUALITY ASSURANCE PROVISIONS. (Yes ___ No ___.)

- Specify mode of transportation (see MIL-T-81821, paragraph 3.2.6, page 21 and MIL-A-8421).

- Specify any other requirements (see DOD INST. 3224.1).

Consider the following wording:

"The trainer shall be transported as specified in the contract. Adequately located and strengthened tie-down points shall be provided. Hoisting or lifting provision shall be included in the design."

Background and Sources: Above text offers sources. This requirement originates from MIL-T-81821, paragraph 3.2.6, (page 21).

Lessons Learned:

3.2.7.1 DISASSEMBLY FOR SHIPMENT.

Rationale and Guidance: This subparagraph should only be used if the size and weight limitations specified in subparagraphs 3.2.3.1 and 3.2.3.2 of the Prime Development Specification severely limit trainer design.

Performance Parameters: Consider the following wording (adapted from MIL-T-81821, pages 21 and 22):

"In the event the size and weight requirements specified in this specification severely limit trainer design for optimum training capability or would result in excessive costs, consideration shall be given to the feasibility of partial disassembly of the trainer for shipment purposes. When partial disassembly of the trainer for shipment purposes is required, appropriate disassembly instructions shall be included along with the trainer."

Background and Sources: MIL-T-81821, pages 21 and 22.

Lessons Learned:

3.2.8 DELIVERY.

"The maintenance trainer delivery requirements shall be as follows: ____."

Rationale and Guidance: This subparagraph should contain the following information.

- Delivery location.
- Delivery date.
- Who has responsibility for checkout when delivery has been made.

Typically the delivery location will be a Government facility. If the contractor or vendor is given responsibility to deliver the trainer at a Government facility, then the contractor or vendor should be given the responsibility to check or inspect the trainer after delivery. If the Air Force is going to accept delivery at the plant where the trainer has been fabricated, it should be so indicated in this subparagraph.

Performance Parameters: Enter delivery location (name of facility, address - including country).

Enter delivery date (day, month, year).

Enter who has responsibility for delivery (U.S. Air Force or contractor). The information supplied in this subparagraph should be consistent with the information provided in subparagraph 3.2.7 of the Prime Development Specification.

Background and Sources: This is a new requirement.

Lessons Learned:

3.2.8.1 INSTALLATION.

"The maintenance trainer installation requirements shall be as follows: ____."

Rationale and Guidance: This subparagraph should specify who has responsibility for installation of the maintenance trainer.

Performance Parameters: Enter who has responsiblity for installation as well as any other requirements concerning the installation (e.g., inspection after installation).

Background and Sources: This is a new requirement.

Lessons Learned: Typically the contractor or vendor is given responsibility to install and inspect the maintenance trainer.

3.3 DESIGN AND CONSTRUCTION.

3.3.1 MATERIALS, PARTS, AND PROCESSES.

"To permit the flexibility and retain adequate quality, the contractor shall: ____."

Rationale and Guidance: It is advisable to allow the contractor or vendor freedom in selecting parts, materials and processes; however, if possible restrictions on this freedom and flexibility should be specified (if any exist).

Performance Parameters: Enter any restrictions on the intended freedom and flexibility. Possible restrictions, limitations, or instructions are offered below:

"To permit this flexibility and retain adequate quality, the contract shall:

a. Require no approval prior to inclusion in the design of trainer from specifications and standards of MIL-STD-143, Group I.

b. Require written approval of the procuring activity for selection of material and process from specifications and standards of MIL-STD-143, Groups II, III, and IV.

c. Require approval from the procuring activity to use nonstandard parts prior to initial procurement."

The above restrictions originate from MIL-T-23991E, page 15.

Background and Sources: See MIL-T-23991E.

Lessons Learned: Allowing freedom and flexibility has worked in the past.

3.3.1.1 PARTS CONTROL PROGRAM. (Yes ___ No ___.)

"The parts control program shall be: ____________________________."

Rationale and Guidance: Parts control programs vary across programs. The parts control program shall be specified in this subparagraph.

Performance Parameters: Enter the parts control program requirements either directly or by reference. Common phrasing appears to be:

"The parts control program shall be in accordance with MIL-STD-965 paragraph 4.3.1 unless otherwise specified herein."

Background and Sources: Only the applicable paragraphs of MIL-STD-965 should be referenced.

Lessons Learned:

3.3.1.1.1 SELECTION OF PARTS.

"In addition to the requirements specified in paragraph 3.3.1.1 of this specification, the following requirements shall apply: ______ ____."

Rationale and Guidance: This subparagraph should be completed if subparagraph 3.3.1.1 of the Prime Development Specification specified a blanket reference to a Military Standard or Specification.

Performance Parameters. The following additional requirements have been included in other specifications or documents and are offered for your consideration:

- All parts to be included in the Program Parts Selection List (PPSL) shall require that the part, whether standard or nonstandard, be currently manufactured by one or more U.S. sources.

- Nonstandard semiconductors and integrated circuits submitted for approval will be approved for use provided they are directly replaceable by a standard part currently being manufactured, or if justified, by a nonstandard part currently stocklisted and being procured by DOD. The proposed part and the replacement part shall be identified in the PPSL.

- The contractor shall maintain a file identifying the source(s) for all parts on the PPSL. The file shall be available to the Government for review.

- The following criteria shall apply to those proposed semiconductors and integrated circuits and the identified replacement parts:

  - Directly replaceable.

- Reliability and performance of the system are not degraded when a replaceable semiconductor or integrated circuit is used (equal or better in form, fit, functions, tolerances, and performance).

- The replacement part is currently being manufactured by at least one United States vendor.

- Drawings shall call out both the original proposed part and the identified replacement part. Spares documentation, technical orders, and other documents shall call out the preferred or recommended part.

- Request for approval to use nonstandard parts shall be submitted prior to initial procurement. Approval by the Government to use a nonstandard part waives the material, process, procedure, and standard composition requirements of this specification for that part only. The part shall not be modified to make it part peculiar.

- Samples of nonstandard parts shall be requested by the procuring activity. These samples shall be submitted in the quantities and to the destination specified by the procuring activity (for tests and examination) (NOTE: Sample quantities can be; exceed one pound of any lubricant, 12 fuses, and 6 units of any other part). Sample parts shall not be returned to the contractor. When there is more than one supplier for a part, parts from each supplier shall be considered for separate submission.

It may be advisable in the text of this subparagraph to define a nonstandard part. The following definition appears in MIL-T-23991E, paragraph 6.2.9 (page 62):

> "A nonstandard part is an item not covered by a specification or standard listed in DOD Index of Specification and Standards (DODISS). Such parts are commercial off-the-shelf items and, in general, are company standards."

A definition is also offered in MIL-STD-965, paragraph 3.3.1 (page 3).

Background and Sources: See ASD Exhibit ENET 75-2D, 10 March 1978 and MIL-5-23991E, paragraphs 3.1.3.1.1 and 3.1.3.1.2 (page 15).

Lessons Learned:

3.3.1.1.1.1 PARTS DOCUMENTATION.

"Parts documentation requirements shall be as follows: ____________
____."

Rationale and Guidance: Parts need to be documented for inventory purposes.

Performance Parameters: Consider inserting the following wording (from ASD Exhibit ENET 75-2D, 10 March 1978; subparagraph 3.3.1.1.1.1, page 6).

> "Parts documentation to substantiate inclusion in the PPSL shall have been submitted or available for Government review prior to parts approval and incorporation into PPSL. Parts documentation in accordance with MIL-STD-965 shall be provided when requested by the Government, for approved parts used in the training device, or for parts identified as replacement parts where such documentation does not exist within Defense Logistics Agency (DESC, DGSC, DISC or DLSC)."

If the above wording is used, the content of subparagraph 3.3.1.1, and 3.3.1.1.1 should be checked to assure consistency and lack of duplication.

Background and Sources: This is a further clarification of paragraph 20.3.1.1 of MIL-STD-490 (page 35). The source for the suggested wording is referenced in the discussion above.

Lessons Learned:

3.3.1.1.1.2 PARTS CONTROL EXEMPTIONS.

"Items exempt from parts control shall be: ______________________
____."

Rationale and Guidance: The vendor or contractor should be informed of those items which are to be exempt from parts control.

It should be made clear that paragraphs 4.7, 4.8, and 4.9 of MIL-STD-965 (pages 5 and 6) specify the following exemptions respectively:

> "Parts contained in unmodified off-the-shelf equipment used in the end item of the contract shall not be

subjected to parts control procedures and listed on the PPSL ... ."

"Parts contained in unmodified GFE used in the end item of the contract shall not be subjected to parts control procedures ... ."

"Structural members and machine parts that are unique and specifically fabricated for a particular application and not adaptable to other equipments shall not be subjected to parts control procedures ... ."

Paragraph 4.7 of MIL-STD-965 may be further modified by the suggestion made below.

Performance Parameters: Reference can be made to paragraphs 4.7, 4.8, and 4.9 of MIL-STD-965; e.g., "Items exempt from parts control shall be in accordance with paragraphs 4.7, 4.8, and 4.9 of MIL-STD-965." However, it may be advisable to include these paragraphs rather than reference them.

If this application requires the use of slide projectors, CRTs, printers, computers, etc. which are commercially available off-the-shelf items, then specific reference to these items should be listed in this subparagraph; e.g.,

"Items exempt from parts control shall be in accordance with paragraph 4.7, 4.8, and 4.9 of MIL-STD-965. In addition the following items shall be considered off-the-shelf items and thus covered under paragraph 4.7 of MIL-STD-965: Computers and directly associated peripheral devices (such as printers, keyboards, disk drivers) not specifically designed for use with the training device, CRT display systems not specifically designed for use with the trainer, and random access slide projector, not designed specifcally for use with the trainer."

Background and Sources: This is a further clarification of paragraph 20.3.1.1 of MIL-T-81821 (page 34) and MIL-STD-965 paragraph 4.7 (page 5).

Lessons Learned: Although MIL-STD-965 paragraphs 4.7, 4.8, and 4.9 exclude certain items they also exempt these items from being listed in the PPSL. Thus, it might be advisable to add the following:

"The above exempted equipment shall be identified and listed in the PPSL under an appendix section title, 'Exempt Equipment'."

In addition the following provision may be included:

"Items not included in the above categories but considered by the contractor to be candidates for parts control exemptions shall be submitted with specific justification, on an individual basis, to the procuring activity for approval."

The wording for both of the above suggestions originates from ASD Exhibit ENET 75-2D, 10 March 1978; page 6.

3.3.1.2 CONDUCTOR IDENTIFICATION.

"Conductor identification requirements shall be as follows: ______ ____."

Rationale and Guidance: The reason conductors need to be marked is to track the conductor when testing and isolating faults on the trainer and to allow ease of assembly and disassembly.

Performance Parameters: Any identification scheme that allows tracking should be permitted. The standard color and numbering codes is offered in MIL-STD-681.

The following requirements should also be considered:

- All conductors which are coded shall follow the same pattern throughout the equipment.
- Cables shall be identified showing the "To - From" termination points.
- Whenever practicable, the coding selected for a particular circuit should follow through connectors, plugs, and receptacles, or interconnecting circuits.
- The identification method used shall not damage the conductor and shall be located such that shielding ties, clamps, or supporting devices will not have to be removed in order to read the identification.
- The following shall be exempt from the above:

- Wires attached by screws or nuts, where the termination point of the wire is obvious and unmistakable should it be removed for service.

- Wires attached by screws or nuts, where two or more wires could be connected interchangeably without altering the electrical circuit (e.g., all connect to ground).

- Point-to-point wiring.

- Wires terminating with soldered connections (other than lugs), taper pins, wire wrap, or termipoint.

• Identification markings shall be permanent and legible. The marking in plastic on metallic materials shall be accomplished by ink stamping, embossing, engraving, silk screening, or stencilling with a smudge proof ink.

Background and Sources: Standards for color and numbering codes offered in MIL-STD-681. Other requirements originate from MIL-T-23991E paragraph 3.2.3.17.5 (page 44).

Lessons Learned:

3.3.1.3 TERMINAL ENDS.

"Terminal ends shall have the following requirements: ____________ ____."

Rationale and Guidance: For tracking and isolation purposes terminal ends need to be marked or identified.

Performance Parameters: Consider the following requirements:

• "Jacket cables and hook-up wire harness shall be marked for identification by use of tubing markers in accordance with MIL-I-631. Type _____, Grade _____, Form _____, and Class _____. (NOTE: MIL-T-23991E specifies Type F, Grade A, Form U, Class I - see paragraph 3.2.3.16.3 of MIL-T-23991E, page 43)."

• "Color-coded ribbon cable shall be exempt from the above requirement when the ends of both originate and terminate in flat cable connectors. 'To - From' information shall still be required."

- "Where space limitations prohibit marking on the terminal (strip on board), the marking shall be on the chassis adjacent to the terminal."

Background and Sources: MIL-I-631, MIL-T-23991E (page 43, paragraph 3.2.3.16.3 and 3.2.3.17.4).

Lessons Learned:

3.3.1.4 SPARE CONDUCTORS.

There are two blanks to be completed, each is discussed below:

a. "Provisions for spares shall be: ______________________________ ____."

b. "The following shall be exempt from the requirements above: __ ____."

Rationale and Guidance: The intent of this requirement is to establish built-in spare conductors for the purpose of future modifications to the trainer. Particular attention must be paid to supply adequate spare conductors in the areas where accessibility to wires is restricted and modification is likely (see subparagraph 4.3.3 of the IDS-Derived Training Equipment Design). In areas where expansion or modification is highly improbable, exceptions may be requested.

Performance Parameters: Consider the following phrasing adapted from ASD Exhibit ENET 75-2D, 10 March 1978 (Addendum 1, page 21), to complete the first blank.

> "All cables or harnesses terminating in connections or terminal strips which contain three or more live conductors shall be provided with spare conductors as listed below. The quantity of spare conductors shall be determined from the total complement of parallel conductors having common to-from points. The spare capacity requirement for flat ribbon cables may be met by providing additional parallel flat ribbon cables. All spare conductors shall be at least the length of the longest conductor in the cable or harness branch."

No of Live Conductors	3 to 5	6 to 12	13 to 20	21 or more
No of Spare Conductors	2	3	4	5 or 20% (whichever is greater)

In the second blank list any exceptions or exemptions from the provisions stated in item a; e.g., "Power distribution cables or point-to-point wiring, such as back planes."

In addition, in the second blank a provision should be made for the contractor or vendor to request exceptions; e.g., "The contractor shall be required to request exceptions from the requirements for spare conductors prior to or at the Critical Design Review."

Background and Sources: Sources have been identified above.

Lessons Learned:

3.3.1.5 FINISHES AND PROTECTIVE COVERINGS.

"The finishes and protective coverings requirements shall be as follows: ______________________________."

Rationale and Guidance: Finishes and protective coverings are specified for safety, appearance, and deterioration reasons.

Performance Parameters: Consider the following list of requirements:

- Appearance (e.g., color). Do not make the provision that the end item equipment shall be the same color as the actual related end item. For training purposes the color may be different (see the fidelity paragraph).

- Personnel safety (e.g., all walking surfaces that are part of the trainer shall be finished with non-skid materials).

- Protection against corrosion and other deterioration (e.g., delamination due to absorption of moisture of laminated finishes; finishes that will crack, peel, chip, or scale should be avoided). The provision should be made that any protective covering against deterioration should in no way prevent compliance with the performance requirements of this specification.

- Application of finishes (see FED Spec-TT-L-32).

- Also see MIL-STD-808 (for specific requirements).

- All display panels surfaces shall be treated to eliminate distracting light reflections and glare.

- All exposed edges shall be free from rough marks, scoring, etc. caused by machining.

- Materials that are nutrients for fungus shall not be used, where it is practical to avoid them. Where used and not hermetically sealed, they shall be treated with fungicidal agents that will render the resulting exposed surface fungus resistant. Fungus resistant materials shall conform to Requirement 4 of MIL-STD-454.

- Brazing of steel, copper, copper alloys, nickel, and nickel alloys shall be in accordance with MIL-B-7883.

- In preparation for painting, after all machining, welding, and brazing operations are completed, the exterior and interior surfaces of all enclosures shall have all rust or other visible corrosive products and flux removed and shall be thoroughly cleaned of all grease, oil, and dirt by solvent wiping, vapor degreasing, or caustic washing and rinsing. Painting shall be in accordance with MIL-F-14072.

The engineer should select requirements based upon the information provided in subparagraphs 3.2.6 and 3.2.6.1 of the Prime Development Specification.

Background and Sources: Sources are identified above. Also see the following: Paragraphs 3.1.6.2, 3.1.6.3, 3.1.6.4, 3.1.6.5, 3.1.6.6, and 3.1.6.6.1 of MIL-T-23991E (page 25) and paragraphs 3.3.1.3, 3.3.1.4, 3.3.1.5, 3.3.1.6, 3.3.1.6.2 and 3.3.1.6.3 of MIL-T-81821 (pages 22 and 23).

Lessons Learned: Do not specify any unnecessary requirements; all specified requirements must be justified in terms of the environment in which the trainer shall be used.

3.3.1.6 POWER.

3.3.1.6.1 PRIMARY POWER SOURCE.

"The maintenance trainer shall be designed to operate from the following power source(s): ________________________________."

Rationale and Guidance: The maintenance trainer may be used in varied environments, requiring varied power sources; e.g., different countries may have different power source requirements.

If a single maintenance trainer is going to be used in different countries with different power supplies, provisions should be made for the same trainer to be used in such electrical power source environments; e.g., through adaptors or conversion units (to be supplied by the contractor).

Performance Parameters: Specify the power supply of the facility which will house the trainer (if the facility is known).

For convenience the following are offered:

- United States: 120/208 VAC, 60 Hertz
  3 phase wye connected
  4 wire, 30 amps per phase

- Belgium: 220 (±5%) VAC, 50 Hertz, single phase [or 380 (±5%) VAC, 50 Hertz, 3 phase, 4 wire]

- Denmark: 120 (+5%, -10%), 50 (±3) Hertz, single phase 15 amp fused [or 120/128 (+5%, -10%) VAC 50 (±3) Hertz, 3 phase wye or delta]

- Netherlands: 220 (±5%) VAC, 50 Hertz, single phase [or 380 (±5%) VAC, 50 Hertz, 3 phase, 4 wire

- Norway: 230 (±5%) VAC, 50 Hertz, single phase (for 230 VAC, 50 Hertz, 3 phase, 3 wire)

If the equipment is operated from mobile electric power generating sources, the requirements of MIL-STD-633B shall apply (see MIL-T-23991E, paragraph 3.2.3.9; page 37).

Background and Sources: See the following: Paragraphs 3.2.1.11.2, 3.2.1.11, and 3.2.1.11.3 of MIL-T-81821 (page 15) and paragraph 3.2.3.10 of MIL-T-23991E (page 37).

Lessons Learned:

3.3.1.6.1.1 TOLERANCES.

"Unbalanced line currents in the system shall not exceed ____ percent of the average simultaneously measured line current. The power factor measured at the primary power source of the total

input shall not be less than ____ percent for any mode of operation."

<u>Rationale and Guidance</u>: There are two blanks to be completed; the percent of unbalance line current and the percent power factor.

<u>Performance Parameters</u>: MIL-T-2991E, paragraphs 3.2.3.10.1 and 3.2.3.10.5 (pages 37 and 38, respectively) suggest a value of 75% for the first blank and 80% for the second value. Unless other values can be justified, the suggested values should be used. The suggested values would meet the desired efficiency on a 3-phase system.

<u>Background and Sources</u>: The suggested values originate from MIL-T-2991E.

<u>Lessons Learned</u>:

3.3.1.6.2 CIRCUIT DESIGN.

<u>Rationale and Guidance</u>:

<u>Performance Parameters</u>: Paragraph 3.2.3.3 of MIL-T-23991E (page 34) states "Circuit design shall be in accordance with MIL-STD-736."

<u>Background and Sources</u>: See MIL-STD-736.

<u>Lessons Learned</u>:

3.3.1.6.3 POWER SUPPLIES.

"The maintenance trainer power supply requirements shall be as follows: ____."

<u>Rationale and Guidance</u>: Power supplies are typically required to convert the primary electrical power service to the required electrical power of the trainer. When completing this subparagraph consideration should be given to the mobile electric power generating sources.

<u>Performance Parameters</u>: Consider the following wording:

> "Solid state electrical power supplies shall be provided to convert the primary electrical power service to the required DC electrical power."

Background and Sorces: The requirements offered above originate from paragraphs 3.2.1.11.7 and 3.2.1.11.8 of MIL-T-81821 (page 16) 16).

Lessons Learned: `400 Hz solid state converters historically provide a high noise level and poor reliability.

3.3.1.6.4 OVERLOAD PROTECTION.

"The maintenance trainer overload protection requirements shall be as follows: ____________________________________."

Rationale and Guidance: Maintenance trainers are typically sophisticated and provisions should be made to reduce any damage that might result from overloads.

In specifying these requirements care should be taken in clarifying:

- Where fuses and circuit breakers should be used.
- Where fuses and circuit breakers should be located (i.e., they should be accessible).
- The need to have parts designed to handle or accommodate overloads.

Performance Parameters: Consider the following adapted from ASD Exhibit ENET 75-2D, 10 March 1978 (page 8):

"Circuit breakers shall be provided within the training device for primary circuits and such other circuits as necessary for protection of the equipment from damage due to electrical overload and excessive heating. Use of fuses will only be permitted when approved by the procuring activity. All fuses and circuit breakers shall be readily accessible and replaceable by locating them directly on the front panels of the equipment. All parts that may be subjected to an overload due to circuit malfunctions, poor adjustment, or part failures shall be designed to accommodate such a load. Where parts cannot be designed to accommodate an overload, circuit breakers shall be provided to protect the unit or assembly. The training device shall be designed for protection from overvoltage, undervoltage, and phase power loss for all three phases of input."

Background and Sources: Source is offered above.

Lessons Learned:

3.3.1.6.5 UTILITY POWER.

"The utility power requirements shall be as follows: ____________ ____."

Rationale and Guidance: The maintenance trainer may be equipped with utility power (for utility lights, utility outlets, and for a maintenance intercom - if needed). If these items are not required then this subparagraph can be omitted.

When completing this subparagraph consider the kind of maintenance the trainer will require. The type of maintenance influences the need for utility power; e.g., if maintenance trainer test equipment is built-in, then utility power will usually not be required, unless lighting during maintenance is required, then utility power for lighting will be needed. Also, if test equipment is to be used, identify specific interconnect cables.

Also in this subparagraph specify the number of utility receptacles (outlets) that shall be needed, as well as the number of utility lights. It has been suggested that as a minimum there should be at least one utility outlet and light per panel trainer. However MIL-T-81821 (paragraph 3.3.1.21.4.1) specifies, "In the case where a trainer consists of two or more trainer panels, two utility receptacles shall be installed on each panel."

If a maintenance intercom is needed specify the need for one.

Performance Parameters: Consider the following wording adapted from ASD Exhibit ENET 75-2D, 10 March 1978 (page 8):

a. "Utility electrical power circuits shall be designed to operate from the primary main power sources and shall be operable while the remainder of the training device power is off. These circuits shall contain the utility outlets. Outlets for portable tools and equipment shall be 3-wire grounding-type utility duplex receptacles. Utility power circuits shall be protected with ground-fault circuit interrupters."

b. "There shall be ___ (number) receptacles, per trainer panel, located at ______________________." (Specify location; e.g., rear of trainer panel.)

c. "There shall be ___ (number) light receptacles located at ________________________________." (Location.)

d. Utility receptacles shall be capable of carrying a 15 amp load minimum.

e. "The maintenance intercom shall ________________." (Specify requirements; if no intercom is required, delete this item.)

Background and Sources: Paragraph 3.4.3 (page 52) of MIL-T-23991E specifies, "To facilitate maintenance, 60 Hz, 120 Volt, ground-typed utility receptacles conforming to W-C-596 Style D, shall be installed ... ."

Paragraph 3.4.4 (page 52) of MIL-T-23991E specifies, "... a maintenance inercommunication system, conforming to MIL-C-299025, shall be installed."

Paragraph 3.3.1.21.4.2 (page 29) of MIL-T-81821 specifies, "When applicable, two easily accessible 115V, 400 Hz power receptacles shall be provided on each trainer panel for use with system test equipment. The receptacles shall be located adjacent to the utility receptacles and shall be appropriately marked. Trainer-peculiar interconnect cables shall be provided, as required, to accommodate the test equipment."

Lessons Learned:

3.3.1.6.6 MAIN POWER DISTRIBUTION PANEL.

"The main power distribution panel requirements shall be as follows: ____."

Rationale and Guidance: When completing this subparagraph consider the following:

- Circuit Design - "The circuit design shall include a main power switch to shut off all power to the trainer without disconnection from the power source" (ASD Exhibit ENET 75-2D, 10 March 1978, paragraph 3.3.1.6.2, page 8). NOTE: Utility circuits should be separately protected.

- Possible Equipment Damage - "A mainpower distribution panel shall be provided and wired in such a manner as to avoid damage to equipment by activation of switches in an indiscriminate or random sequence" (ASD Exhibit ENET 75-2D, 10 March 1978, paragraph 3.3.1.6.6, page 8).

- Contents of Panel - "A power distribution panel shall be provided and shall contain the electrical busses and disconnects" (MIL-T-23991E, paragraph 3.2.3.10.9.2, page 38). "This panel shall contain the master keyed lock switch, elapsed time meter(s), 'Power On' light(s), warning lights(s) as required" (MIL-T-81821, paragraph 3.3.1.21.6, page 30.)

- Location of Panel - "The power control panel shall be installed in a clearly visible location" (MIL-T-81821, paragraph 3.3.1.21.6, page 30).

- Number of Power Control Panels - "Each trainer, independently operable trainer panel, and panel group which requires external electrical, hydraulic, or pneumatic power shall be provide with a power control panel" (MIL-T-81821, paragraph 3.3.1.21.6, page 30).

Performance Parameters: Select the appropriate wording from the above paragraph. If certain items are contained on the panel, they should be further clarified. Consider the following wording when specifying these:

Master Keyed Lock Switch - "A master keyed lock switch shall be provided on each trainer power control panel to control the availability of power from components of the trainer panel. Power for the test equipment receptacles on the trainer panel shall bypass the master keyed lock switch. The switch or circuit breaker shall return to and remain in the 'OFF' position in the event of power interruption. The switch shall be marked as specified herein." (MIL-T-81821, paragraph 3.3.1.21.6.1, page 30.)

If master key lock switch is not going to be used, then specify the protect instrument (e.g., enter a code in the provided keyboard).

Power On Light - "A separate one (1) inch diameter red pilot light for each type of electrical, hydraulic, and pneumatic power required shall be installed on each trainer power control panel in a clearly visible location. The light(s) shall be appropriately marked to indicate 'POWER ON' for the master switch, and for each type power required for the trainer panel. The light(s) shall illuminate when the applicable type of power is available on the trainer panel." (MIL-T-81821, paragraph 3.3.1.21.6.4, page 30; also see paragraph 3.2.3.10.9.3, page 39, of MIL-T-23991E.)

NOTE: Time totalizers are specified in subparagraph 3.3.1.8 of the Prime Development Specification.

Background and Sources: Sources are referenced in the above two paragraphs.

Lessons Learned:

3.3.1.6.7 POWER INTERRUPTION AND TRANSIENTS.

a. "... the following nonsimultaneous conditions of power sources: ______________________________."

Rationale and Guidance: Power interruptions can cause problems for and damage to the trainer. It is not necessary for the trainer to continue during a power interruption.

Performance Parameters: MIL-T-23991E, paragraph 3.2.3.10.4 (page 37) specifies:

- "An interruption with power restored within 3 to 30 seconds occurring not more than once every five minutes.
- A voltage transient of three and one-half (3.5) times nominal voltage to one-tenth (0.1) of normal voltage but short duration (less than one cycle).
- A frequency variation of plus or minus 15 percent for periods up to ten seconds occuring not more than once every five minutes."

Background and Sources: Source specified above.

Lessons Learned:

3.3.1.6.8 GROUNDING.

"The grounding requirement shall be as follows: ______________________________ ______________________________."

Rationale and Guidance: This subparagraph is included for safety consideration as well as for the proper operation of the trainer.

Performance Parameters: MIL-T-81821, paragraph 3.3.1.24.2 specifies the following:

"All non-current-carrying conducting materials such as metallic conduit, cable sheath or armor, enclosures, and switch boxes, which could short to potentials greater than 30 V, shall be electrically bonded and connected to a common ground buss, which shall be connected to the grounding terminal of the power input receptacle."

The following additional requirements are adapted from MIL-T-23991E (pages 39 to 42):

"Primary power circuits shall not be directly grounded within the training device. All neutrals shall be made common at the power source neutral buss. The neutral buss of the power sources shall be routed through equipment power panels to earth potential at one point."

"Where required power line interference filters shall be referenced to chassis ground. Power line interference filters shall meet the electromagnetic compatibility requirements specified within this document."

"Signal frequencies of 150 kHz or less and pulsed signals with rise and fall times equal to or greater than five microseconds shall utilize a grounding system insulated from the chassis and prime power ground within the training device. Analog systems which have frequencies less than 20 kHz shall use a grounding system that is referenced to a single point to avoid duplicate and common signal ground return paths."

"Signal frequencies greater than 150 kHz and pulsed signals with rise and fall times less than five microseconds may utilize chassis as signal ground. Signal interfaces with equipments not in this category shall be properly isolated to ensure noncompromise of the lower-frequency equipment signal ground system. High-frequency grounding (bonding) straps shall have a length-to-width ratio of 5:1 and a minimum thickness of 0.025 inches."

"Cabinets, consoles, racks, and equipment shall have a signal ground point isolated from chassis. The signal ground point shall be located less than two inches from the chassis ground point. The junction resistance between the signal ground bus and a signal ground point shall not be greater than 0.5 milliohm."

"Equipment cases, cabinets, racks, and enclosures shall be referenced to the chassis grounding system. The chassis grounding system shall provide for a fault-current return path for personnel shock hazard safety and a low impedance path for RF currents for the training device electrical or electronic equipments. The resistance between any two chassis ground interfaces shall be less than 5.0 milliohm. Plugs and convenience outlets for use with portable tools and equipment shall have

provisions for automatically grounding frame, case, or housing of tools and equipment, for personnel shock hazard safety, when the plug(s) is mated with a receptacle(s) that conforms to W-C-596."

"Cable and wire shield grounding termination practices shall be consistent with the frequencies and the interference and susceptibility levels of wires and cables being shielded. The following shield grounding methods shall be used:

a. Shields used for low-frequency signal lines shall be terminated at one end only.

b. Shields used for high-frequency signal lines may be terminated at each end.

c. Coaxial cable shields for low-frequency, low-level signal lines shall be floated from chassis.

d. Conduit and external metallic sheath used for overall cable shielding shall be terminated to chassis ground at each end by direct contact around the periphery of the shield.

e. Shields used for restricting high-frequency interference and relay lines shall be terminated to chassis ground at each end."

Background and Sources: Sources are referenced above.

Lessons Learned: Many hard to find electrical problems have been attributed to poor grounding practices.

3.3.1.6.9 WIRING, GENERAL.

Rationale and Guidance: There should be a general statement concerning wiring.

Performance Parameters: MIL-T-81821 specifies the following (page 31): "Specification MIL-W-5088 shall be used as a guide for wiring trainer panels. The wiring shall be equal to the best commercial standards and adequate for the trainer requirements."

The engineer should carefully review MIL-W-5088 to determine if all paragraphs are applicable.

Background and Sources: Above discussion specifies source.

Lessons Learned: Many contractors have mistakenly used undersized wiring.

3.3.1.6.9.1 WIRING REQUIREMENTS.

"The wiring requirements shall be as follows: ____________________ ____________________."

Rationale and Guidance: Consideration should be given to the following requirements. These requirements can be specified within this subparagraph or they can be separated into their own subparagraphs:

- Wire Bunding.
- Shielding
- Wiring and Cabling/Cable Classification.
- Insulation Protection.
- Cable Support.
- Printed Wiring.
- Electrical Connectors.

Information on each of these is offered in the discussion below.

Performance Parameters: Each of the above items is discussed:

- Wire Bundling: MIL-T-81821, paragraph 3.3.1.29.1 specifies the following:

  "All wiring shall be neatly bundled. Continuous lacing shall not be used for bundling. Wiring or bonding which is not typical of the related end item shall be hidden from the students' view, preferably behind the trainer panel, or concealed in an existing harness."

- Shielding: MIL-T-81821, paragraph 3.2.1.30 (page 34), specifies the following:

  "Shielding shall be provided to protect sensitive, low power level circuits against the electromagnetic interference effects of conducted or radiated radio frequency energy whether internally or externally generated. Shielding shall not prevent replacement of defective wafers."

  while MIL-T-23991E, paragraph 3.2.3.15.2, page 43 specifies:

"Conductors using metallic shielding unprotected by an outer insulation shall be secured so as to prevent the shielding from coming into contact with exposed terminals or conductors. Shielding shall be terminated at a suitable distance to ensure adequate insulation from the exposed conductor to prevent shorting or arcing between the conductor and the shielding."

- Wiring and Cabling: MIL-T-23991E, paragraph 3.2.3.14 (page 41) specifies:

  "Wire and cabling routing shall provide the isolation requirement specified herein. Interconnecting cables between cabinets and enclosures shall enter from the rear, top, or bottom of cabinets or enclosures."

- Cable Classification: MIL-T-23991E, paragraph 3.2.3.14.1 (pages 41 and 42) specifies:

  "Interference-producing or interference-sensitive wires and cables classified below shall meet the electromagnetic interference (EMI) criteria specified herein:

  a. Class I - Class I consists of wires and cables between equipments or circuits that are not interference-producing. Examples of this class are:

     (1) AC power wiring.

     (2) Relay and stepping-motor wiring.

     (3) Actuating power wiring.

     (4) Flashing incandescent and fluorescent light wiring.

  b. Class II - Class II consists of wires and cables that, in themselves, are not interference-producing but are connected to interference-sensitive equipments or circuits. Examples of this class are:

- Cable Support: ASD Exhibit ENET 75-2D, 10 March, 1978 (page 10) suggests the following:

  "Conductors not placed in ducts or channels shall be bound into a cable and securely held by insulating clamps or other suitable means, except where point-to-point wiring or commercial equipment is used. Cables shall be supported at least every 24 inches to prevent abrasion from folding, vibration, or other mechanical damage. Where not contained in ducts or channels, interconnecting cables or harnesses between assemblies and units shall be contained within extruded plastic or synthetic or rubber tubing.

- Printed Wiring: ASD Exhibit ENET 75-2D, 10 March 1978 (page 10) suggests the following:

  "Except as noted herein, printed wiring shall be in accordance with Requirement 17 of MIL-STD-454. For equipment used only in the environmental conditions of this specification and when circuit leakage is not critical, a solder mask meeting the Requirements of IPC-SM-840, Class III may be substituted for conformal coating."

- Electrical Connectors: ASD Exhibit ENET 75-2D, 10 March 1978 (page 10) suggests the following:

  "Requirement 10 of MIL-STD-454 shall apply. MIL-C-38999 and MIL-C-83723, MIL-C-55302 and MIL-C-39012 covering circular, printed circuit board, and RF connectors, respectively, are preferred when these types of connectors are used. MIL-C-83503 shall apply for flat cable connectors."

Other possible requirements are:

- Slack:

  "For flexible conductors, including those within cables terminating in multiterminal headers or receptacles, slack shall be provided to permit not less than two replacements of the part, with the exception of radiofrequency (RF) leads, where the length must be made as short as possible for electrical reasons," or "Sufficient slack shall be

provided in all wiring to permit a minimum of three (3) receptacle replacements. Connectors shall be provided at all disassembly points on trainers requiring disassembly for shipment"; this can also be phrased as (see MIL-T-81821, page 32) "Where it has been determined that it will be necessary to relocate a radio, radar, or electrical system component from the stowage shelf for installation on the bench top for instructional purposes, sufficient length of cable or patch cords shall be provided to permit the units to be removed to the work area on the bench top without affecting their operation. Space for stowage of the extra lengths of cable or patch cords shall be provided."

- Voltage Drop: "The voltage drop requirements of MIL-W-8160 shall apply" (MIL-T-23991E, page 42).

- Current-Carrying Capacity: "Current-carrying capacity of wires and cables shall be in accordance with MIL-W-8160 (MIL-T-23991E, page 42).

Background and Sources: Sources are specified above.

Lessons Learned:

3.3.1.7 MECHANICAL CONNECTORS.

"Mechanical connector(s) requirements shall be as follows: ________ ____."

Rationale and Guidance: Often maintenance trainers have mechanical connectors for hydraulic and pneumatic power hoses. This subparagraph provides an opportunity to specify the connector requirements.

Performance Paramaters: MIL-T-23991E, paragraph 3.2.3.15.1 specifies:

> "Mechanical connections shall be supported to prevent breakage and changes in performance due to vibration, inclination, or shock encountered under specific service conditions specified in the detail specification. Wire terminations shall be in accordance with the mechanical connections requirements of MIL-S-45743."

Furthermore, paragraphs 3.3.1.33 and 3.3.1.34 of MIL-T-81821 specify the following:

> "Each trainer, independently operable trainer panel, or panel group which requires the use of hydraulic or pneumatic power shall be provided with twenty-five (25) foot flexible hoses, as required, for connecting the trainer panels to the facility or trainer hydraulic or pneumatic power supply system or for trainer panel interconnect, as applicable. Appropriate female quick disconnect fittings, with dust covers, shall be installed in each end of each hydraulic or pneumatic hose to provide for mating with the male quick disconnect fittings on the trainer panels and the facility hydraulic or pneumatic power supply system. When pressure and volume flow is the same, all hydraulic pressure hoses shall be interchangeable and all hydraulic return flow hoses shall be interchangeable; however, hydraulic pressure hoses and return flow hoses shall not be interchangeable with each other. When pneumatic pressure and volume flow is the same all pneumatic hoses shall be interchangeable with each other."

> "Individual trainer panels requiring external hydraulic or pneumatic power shall have hydraulic/pneumatic manifolds with appropriate male hydraulic quick disconnects or pneumatic fittings installed on the rear center of the panel, and shall be capable of conducting hydraulic or pneumatic power through the manifold connections to two (2) or more related trainer panels, with the individual trainer panel power either 'OFF' or 'ON' when connected in series from a single hydraulic or pneumatic power source. Each maintenance trainer and individual trainer panel which is not part of a panel group shall be capable of independent operation when connected to the power supply, and shall contain an appropriate control panel for this purpose. Connectors shall be provided at all disassembly points on trainers requiring disassembly for shipment."

Background and Sources: Sources are specified in the above discussion.

Lessons Learned:

3.3.1.8 TIME TOTALIZERS.

"The time totalizers requirements shall be as follows: ____________ ____."

Rationale and Guidance: Time totalizers are used to measure time of operation, time of power-on, etc. Maintenance trainers should be provided with totalizers, so that operational costs can be computed and maintenance actions recorded.

Performance Parameters: MIL-T-81821, paragraph 3.3.1.22 (page 31) specifies the following:

> "Four-digit time totalizing meters conforming to MIL-M-7793 registering in one hour increments shall be installed on each power conversion unit to register total hours of operation and on each trainer, independently operable trainer panel and panel group as required to separately record the following where applicable:
>
> a. A meter on the equipment side of the master keyed lock switch to record total number of hours that power is used for equipment which is normally on stand-by when the lock switch is in the "ON" position.
>
> b. A meter on the equipment side of the master keyed lock switch to record the total number of hours that power is used for the actual operation of the trainer and components or equipment installed thereon.
>
> c. A meter to register the total number of hours that power is used by the trainer for the operation of support equipment through the trainer power receptacles.
>
> d. A meter shall be installed to record the total hours of operation of each power conversion unit.
>
> On short cycle operations type trainers, such as landing gear, speed brake and arresting hook trainer panels, for which hours of actual operation would not provide a meaningful measure of trainer utilization, an operational cycle counter may be substituted for the elapsed time meter registering total hours of actual trainer operation."

MIL-T-23991E, paragraph 3.3.3, page 50, adds the following:

> "A time totalizing meter shall be utilized in the power distribution panel . . . Time totalizing meters shall also be installed on the major subsystems which may be

used independently of each other for fractions of the total trainer time. The meters shall have at least five digits in increments of one hours."

The difference in the number of digits must be reconciled.

Also the number of totalizers should be specified; consider the following places where a totalizer might be required:

- Computer.
- Perpherical devices (e.g., printer).
- Visual display system (e.g., slide projector).
- Each hydraulic pump.
- Main power supply.

Background and Sources: Sources are specified above.

Lessons Learned:

3.3.1.9 SCREW AND PIPE THREADS.

"Screw and pipe threads shall be as follows: ____________________
____."

Rationale and Guidance: This subparagraph provides an opportunity to specify any requirements for threads.

When supplying the text for this subparagraph consideration should be given to the following:

- Type of threads desired (do not forget about the standards in foreign countries, if the trainer is to be used in foreign countries).

- Type of threads desired for adjustments.

Performance Parameters: MIL-T-23991E, paragraphs 3.2.2.11.3 and 3.2.2.11.4 specify respectively:

"Unless approved by the procuring activity, parts with threads other than those specified in requirement 12 of MIL-STD-454 shall not be used."

"Threaded devices used for adjustment purposes shall conform to either the unified-coarse or fine-thread series in accordance with National Bureau of Standards, Handbook H28."

In addition, paragraph 3.2.2.11.7 of MIL-T-23991E, states the following:

"Commercial utility parts, such as: screws, bolts, nuts, washers, pins, rivets and similar small parts having suitable properties may be used provided that:

a. They can be replaced by standard parts (MS or AN) without alteration.

b. The corresponding MS or AN standard part number is referenced in the part list and on the training device drawings."

Background and Guidance: Sources are referenced in the discussion above.

Lessons Learned:

3.3.1.10 THERMAL DESIGN.

"Thermal Design requirements shall be as follows: ____."

Rationale and Guidance: Heat build up can cause severe damage to the equipment. In addition, dust within enclosed cabinets can cause severe damage to the trainer; dust can be controlled by using filters. Heat build up requires a cooling system.

Performance Parameters: Protection of parts due to dust, soot, or insects should be considered. MIL-T-23991E, paragraph 3.2.1.4 (page 28) states the following:

"Internal parts of the training device subject to damage, change in physical characteristics, or malfunction from the accumulation of dust, soot, insects, or other contamination shall be protected from the direct path of natural or forced air circulation by filters."

ASD Exhibit ENET 75-2D, 10 March 1978 (page 10) adds the following comment:

"The filters shall be either replaceable or reuseable with easy access for periodic cleaning and replacement."

For heat control, MIL-T-23991E, paragraph 3.2.1.5.2 states:

"Thermal design of electronic equipment shall be in accordance with Requirement 52 of MIL-STD-454.

MIL-T-23991E, paragraph 3.2.1.5 (page 28) further clarifies heat control:

"The training equipment design shall provide for part, assembly, and cabinet operation in a thermally ambient temperature, without hot spots, when operated within the temperature and environmental conditions specified in the specification. When forced air cooling is used the following guidelines shall apply:

- Fans and blowers shall operate from the equipment power source.

- Air filters shall be located at all intakes and shall be removable to permit cleaning without disassembly of the equipment.

- Openings or ducts shall be provided to carry the exhaust air away from the unit. Where heated air may affect the room temperature, the heated air shall be exhaused outside.

- All exhaust openings shall be located at the top, rear or side of the training equipment consistent with the location of associated cabinets and equipment.

- Fans or blowers shall be placed at the intake end of the duct.

- The maximum air velocity through the enclosures shall not exceed 900 ft/min.

- Electronic equipment enclosures shall be of the ventilated type as defined in MIL-STD-108. All cabinet enclosures except those remotely located shall have air inlets for use with forced air ventilation."

The use of blowers is further clarified in the same document on page 21, "Blowers for cooling electronic equipment shall conform to MIL-B-2307."

MIL-T-23991E, paragraph 3.2.1.5.3 (page 29) discusses wattage dissipation:

"Where wattage dissipation calculations indicate heat problems, the design of the affected equipment shall be governed by thermal considerations. The following are some methods of solution:

- Provide structural conductors to carry the heat to the extremities of the unit.
- Provide radiating areas and, if needed, fins to permit convection of the heat.
- Isolate heat dissipating parts and subassemblies to prevent heat flow into adjacent parts.
- Employ completely bonded heat sinks for all heat dissipating parts.
- Use materials and parts of proven thermal capabilities."

And finally, paragraph 3.2.1.8 of MIL-T-81821 further clarifies when cooling is required:

"Trainer panels or items of equipment containing heat-producing components shall be designed and arranged so that stabilized operating temperatures do not exceed the rated temperatures of parts, equipment, and components exposed thereto. If this cannot be accomplished, adequate provisions shall be made for the removal of heat. Where the rate of heat emission is too high to warrant reliance upon natural convection for cooling, forced ventilation shall be installed. Such ventilation shall prevent the stabilized operating temperatures of parts, components, and equipment mounted in the enclosures from exceeding their rated temperatures with an ambient air temperature of 90° F. Under any condition of operation, at an ambient temperature of seventy-seven (77°) F, the temperature of exposed parts and surfaces shall not exceed one hundred and forty degrees (140°) F, except that the operating controls and control panels shall not exceed one hundred degrees (100°) F. Trainers shall be capable of operating continuously for 4 hours or for the three complete cycles of operating, whichever is longer, without overheating or damaging the equipment."

Background and Sources: Sources are referenced in the above discussion.

Lessons Learned:

3.3.1.11 FASTENERS.

"Fasteners used on the trainer shall meet the following requirements: ____."

Rationale and Guidance: There are many kinds of fasteners that can be used; e.g.,

- Trainer-peculiar fasteners.
- Screws.
- Clamps.
- Locking devices.

This subparagraph provides an opportunity to specify the requirements for such fasteners.

Performance Parameters: MIL-T-81821, paragraph 3.3.1.13 discusses trainer-peculiar fasteners:

> "Trainer peculiar fasteners used to secure removable components, caster, access doors and other detachable items shall require a minimum number of turns to the locked position commensurate with stress requirements. Captive type one-quarter (1/4) turn fasteners shall be used where feasible."

MIL-T-23991E, paragraph 3.2.2.11, specifies:

> "The application of fasteners and fastenings shall be in accordance with requirement 12 of MIL-STD-454 ... ."

The same document in paragraph 3.2.2.11.1 specifies requirements for locking devices:

> "Locking devices shall be capable of retaining the controls in any given setting within the range of control. The locking and unlocking action shall not affect the setting of the control. Where verniers are used, the locking device shall operate on both main and vernier controls."

Clamps are further specified in paragraph 3.2.2.11.2 of MIL-T-23991E:

> "All plug-in electronic parts and electron tubes shall be securely retained by clamps where necessary to meet the shock and vibration requirements of the detail specification. Clamps, when used, shall be capable of being easily released for item replacement."

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Flathead screws and panel-mounting screws are also discussed in paragraphs 3.2.2.11.5 and 3.2.2.11.6, respectively, of the same document:

> "Flathead screws shall not be used in sheet or thin-walled material having a thickness of less than one and one-half times the height of the head of the screw. Wherever flathead screws are used, the screw head shall be completely seated in the material."

> "Panel-mounting screws shall be limited to oval-head or recessed flush-head screws."

Background and Sources: Sources are referenced in the above discussion.

Lessons Learned:

3.3.2 ELECTROMAGNETIC COMPATIBILITY.

"The maintenance trainer shall have the following electromagnetic compatibility requirements: ________________________________ ____."

Rationale and Guidance: The training device must be compatible with itself and with the facility in which it will be housed.

Performance Parameters: Consider the following wording from ASD Exhibit ENET 75-2D, 10 March 1978:

> "The training device shall be electromagnetically compatible with itself, the other equipment in the same facility, and with the environment. Adequate shielding and circuit separation shall be designed into the training device, and where classified information will be processed, the design shall be in accordance with the guidelines of AFR 100-54. The complete training system shall comply with the conducted and radiated interference suppression requirements of MIL-STD-461 for Class B4 equipment. Abbreviations and terms used in conjunction wtih EMI shall be in accordance with MIL-STD-463. The requirements of MIL-E-6051 shall apply. MIL-STD 462 shall be used as a guide for testing the requirements of MIL-STD-461."

Background and Sources: Sources are specified above.

Lessons Learned:

3.3.3 NAME PLATES AND PRODUCT MARKINGS, GENERAL.

a. "Unless otherwise specified herein, name plates and product markings shall be:____."

b. "Control panel markings shall be: _________________________."

c. "Abbreviations used in marking shall be: _____________________ ____."

Rationale and Guidance: This is a header paragraph, which establishes some general requirements. Specific requirements are further presented and discussed in the subparagraphs to follow.

Performance Parameters: Item a is typically completed by: "... in accordance with MIL-STD-130."

Item b is typically completed by "in accordance with MIL-STD-1472."

Item c is typically completed by "in accordance with MIL-STD-12."

However, before imposing such blanket requirements the engineer should review each of the above mentioned standards. If exemptions are indicated for this application, these exemptions should be specified.

Background and Sources: Sources are specified above.

Lessons Learned:

3.3.3.1 NAME PLATES.

"Name Plates shall meet the following requirements: ______________ ____."

Rationale and Guidance: Name Plates provide a means for end item identification.

Performance Parameters: MIL-T-81821, paragraph 3.3.3.2 (page 37) establishes the information requested on the Name Plates.

"An aluminum or brass data plate, one-eighth (1/8) inch thick, permanently and legibly engraved or stamped with the following information, shall be securely attached to each trainer panel in a place not readily visible to the student."

Military Serial Number	*
Trainer Nomenclature	*
Panel No. * of * panels	*
Related End Item Serial No. Reflected	*

Configuration:

	Cube	Height	Width	Length	Weight	Floor Loading With Casters	Floor Loading Without Casters	Floor Loading With Jack Pads
Operating	*cu.ft.	*in.	*in.	*in.	*lbs.	+*PSI.	*PSI.	*PSI.
Shipping	*cu.ft.	*in.	*in.	*in.	*lbs.	+*PSI.	*PSI.	*PSI.

Manufacturer's Name and Code	*
Manufacturer's Part Number	*
Manufacturer's I.D.	*
Federal Stock Number (when applicable)	*
Name of Contractor	*
Contract Number	*
Acceptance Insp. Date	*
Property of U.S. Government	*

* Applicable data shall be entered in maximum extended dimensions.
+ Maximum single caster load.

NOTE: The serial number shall be established by the procuring activity.

NOTE: When applicable the contractor or vendor shall obtain the Federal stock number in accordance with MIL-STD-26715.

In addition to the above requirement MIL-T-81821, paragraph 3.3.3.5 states:

> "A legend plate containing the related series end item designation and the applicable system designation therein shall be engraved in neat, well-formed Gothic characters approximately one (1) inch high on standard black-white-black engraving stock. The plate on each trainer panel shall be readily visible to the students. The trainer panel number, if a multipanel trainer, shall be included on the legend plate."

Background and Sources: Sources are referenced in the discussion above.

Lessons Learned:

3.3.3.2 PARTS IDENTIFICATION.

"The parts identification requirements shall be as follows:____."

Rationale and Guidance: For ease of replacement and identification, parts should be marked. Parts should be marked to the RU level.

If cards or boards are to be marked, consider using the matrix method.

Performance Parameters: MIL-T-81821, paragraph 3.3.3.6 (page 38) offers the following:

> "The name of each major part of assembly shall be engraved, photographed, etched, etc., by the most economical method on suitable nonferrous material in neat, well-formed characters, one-quarter (1/4) to one-half (1/2) inch high, on standard black-white-black engraving stock plates, or black anodized aluminum stock. The plates shall be located on or adjacent to the corresponding part. Each major part of assembly shall have identical markings and instructions on or adjacent to it as those on the actual related end item."

ASD Exhibit ENET 75-2D, 10 March 1978, offers the following wording:

> "Reference symbol designations shall be assigned to electrical and electronic component assemblies in accordance with ANSI Y32.16. Mechanical symbols shall be in accordance with MIL-STD-17. Symbols for electrical and electronic diagrams shall be in accordance with ANSI Y32.2."

Background and Sources: Sources are referenced in the discussion above.

Lessons Learned:

3.3.3.3 COVER MARKING.

"Cover Marking requirements shall be as follows: ______________ ____."

Rationale and Guidance: First, it must be determined if there is going to be a cover (e.g., dust cover). If a cover is required, that cover can be described in this subparagraph or can be described in paragraph 3.7 of this specification (e.g., identify cover material such as wood or fabric and identify size of cover).

Also described in this subparagraph should be any markings that appear on the cover(s).

Performance Parameters: Specification No. 16PS028A, paragraph 3.3.3.13 provides a good example of a description of a fabric cover:

> "A dust and security cover shall be provided for each unit (MSCC and DP) to provide protection against damage due to collection of dust during periods of non-use. These covers shall be fabricated of a light-weight fabric material, conforming to MIL-C-20696, Type 1, Class 3, Color 15102 in accordance with FED-STD-595. Covers shall be designed to fit the individual unit in both the shipping and operating configuration."

The same specification in paragraph 3.3.3.14 also provides a good description of a hard cover:

> "Hard covers shall be provided for protection against weather and handling during shipment. The hard covers shall disassemble for storage into separate units; i.e., two ends, two sides, a lid, and a base. The base shall serve as a skid and shall include forklift provisions. Casters are not required on the base unless they are demountable and stowage provisions are included in the assembled hard cover. In the event casters are provided, they shall be swivel lock, brake type casters. The separate units of the hard covers shall assemble through the use of mechanical locking devices such as high strength, hexagonal wrench-operated, rotary type latches. In no case shall assembly of the component units into a hard cover require the use of screws or nails. Means shall be provided to firmly secure the SAMT unit (DPs or MSCC) to the hard cover base before assembling the hard cover. The remaining hard cover components shall have adequate shock absorbing materials and/or restraint devices to immobilize the unit (DPs or MSCC) during transportation."

For further information concerning the construction of covers see paragraphs 3.7.5, 3.7.5.1, 3.7.5.2, and 3.7.5.3 of MIL-T-81821.

In terms of marking, MIL-T-81821, paragraph 3.3.3.7 (page 38) offers the following wording for outer covers in general:

> "Applicable cover markings shall appear on both the longer sides of the upper edge of each trainer cover. Inner dust/security covers shall be marked with the appropriate security classification in red letters not less than two (2) inches high. The word FRAGILE shall be appropriately marked on each of the four sides of the outer trainer cover using red letters 2 inches high. Adjacent to these markings shall be a vertical red arrow and the legend THIS SIDE UP in letters 1 inch high. Each outer cover shall be permanently and legibly marked with the following information in three-quarters (3/4) inch high white letters:

Federal Stock Number	* (when applicable)
Military Serial Number	*
Trainer nomenclature	*
Panel No. * of * Panels	*
Configuration	*

Cubage	Height	Width	Length	Weight	Floor Loading With Caster	Floor Loading Without Casters	Floor Loading With Jack Pads
*cu.ft.	*in.	*in.	*in.	*lbs.	+*PSI.	*PSI.	*PSI.

* Applicable data in shipping conditions shall be entered.
+ Maximum single caster load.

MIL-T-81821, paragraph 3.3.3.7.1, also offers the following on security covers:

> "On all trainers classified CONFIDENTIAL or higher, the inner fabric security cover shall be marked with the appropriate security classification in red letters not less than two (2) inches high. These letters shall appear against a white or similar high contrast background. The security classification shall not be indicated on the exterior of the outside cover."

MIL-T-81821, paragraph 3.3.3.7.2 (page 39) offers the following wording concerning hard covers:

> "A weatherproof decal with instructions for removal of the hard cover and installation of the casters shall be placed on the cover near the caster access door."

MIL-T-81821, paragraphs 3.3.3.17 and 3.3.3.18 (pages 40 and 41) also indicate the need to have instructions for the assembly of the cover as well as the installation of the cover:

> "When hard outer covers are provided, one corner of the cover and a corresponding point on the trainer base panel shall be appropriately marked to indicate the correct installation of the cover assembly."

Also of concern may be cover handles; consider the wording suggested by MIL-T-81821, paragraph 3.3.3.18 (page 41):

> "When hard outer cover handles are provided, which are not suitable for hoisting or cargo plane tiedown attachment, the following legend shall be centrally located above the handles on each side or end of the cover in red letters approximately 1 inch in height:
>
> WARNING
> FOR LID LIFT ONLY

Background and Sources: Sources are referenced in the discussion above.

Lessons Learned:

3.3.3.4 PRECAUTIONARY MARKINGS.

"The precautionary marking requirements shall be as follows: _____
____."

Rationale and Guidance: Precautionary markings should be used when a part from the real equipment has been modified and used on the trainer.

Performance Parameters: MIL-T-81821, paragraphs 3.3.3.9 and 3.3.3.10 offer the following wording, respectively:

"When modified, rejected or non-operable parts are used, the trainers shall be appropriately marked by metal plate, decalcomania, etc., as follows:

PARTS AND COMPONENTS OF THIS TRAINER WHEN INDIVIDUALLY MARKED MODIFIED, REJECTED OR NON-OPERABLE ARE TO BE USED FOR GROUND TRAINING PURPOSES ONLY."

"Modified parts which by means of depot level overhaul could be returned to Ready For Issue/Servicable (RFI) condition for operational use on the related end item shall be appropriately marked by stenciling or decals as follows 'MODIFIED--NOT FOR OPERATIONAL USE'. All rejected, non-operable parts and those modified parts which could not by means of depot level overhaul be returned to RFI conditions for operational use on the related end item shall be individually and permanently marked by stamping or engraving 'REJECTED--NOT FOR OPERATIONAL USE'. Where the size of part renders marking impractical or ineffective, the next higher assembly in which the part is used shall be so marked. Such marking will not be required on obviously cutaway parts."

ASD Exhibit ENET 75-2D, 10 March 1978, paragraph 3.3.3.2 also suggests the following marking on modified parts:

"Where modification of parts, subassemblies, assemblies, or units of ground, air, or space vehicles, or equipments is reflected in the applicable training equipment drawings, the pertinent drawing number shall also be marked on the next assembly drawing and stamped on the unit."

Background and Sources: Sources are referenced in the discussion above.

Lessons Learned:

3.3.3.5 SAFETY MARKINGS.

"The safety marking requirements shall be as follows: ____________
____."

Rationale and Guidance: When there are hazards associated with the trainer, warning signs should be required.

Performance Parameters: MIL-T-81821, paragraph 3.3.3.20 (page 41) specifies the following:

> "All safety hazards shall be provided with adequate and conspicuous warning signs. Signs ... shall display the words STAND CLEAR in 1/2-inch high white letters on red translucent material. Trainers generating electromagnetic radiation shall have the minimum safe distances identified and marked."

Paragraph 3.3.6.1 of MIL-T-81821, specifies the following:

> "A back-lighted warning sign shall be centrally located on each of the four sides of all trainers used to demonstrate the operation of fast-acting mechanisms such as landing gear, flight controls, control surfaces, and speed brakes. The warning sign shall be illuminated any time the power source is turned on at the trainer. The warning lamp shall be enclosed in a metal box, the front surface of which shall be of a red translucent material not less than two (2) by three and one-half (3 1/2) inches ... ."

Background and Sources: Sources are referenced above.

Lessons Learned:

3.3.3.6 ELECTRICAL POWER MARKINGS.

"The electrical power marking requirement shall be as follows: ______________________________."

Rationale and Guidance: To avoid misuse of the trainer, in terms of power, the electrical requirements of the trainer should be clearly marked on the trainer.

Performance Parameters: MIL-T-81821, paragraph 3.3.3.13 (page 40) specifies the following:

> "The electrical power required to operate each trainer, independently operable trainer panel, panel group and related trainer powered support equipment under specific load conditions shall be permanently marked on a plate similar to the manufacturer's data plate. The plate shall be permanently attached adjacent to the master keyed lock switch and shall indicate the following as applicable:

Power Requirements			Amperage		
Voltage	Frequency	Phase	Standby	Start	Operate
28V	DC		*	*	*
120V	60 Hz		*	*	*
120V	400 Hz	Single	*	*	*
120/208V	400 Hz	Three			
		A	*	*	*
		B	*	*	*
		C	*	*	*

* Applicable data shall be entered."

Performance Parameters: A source is referenced in the discussion above.

Lessons Learned:

3.3.3.7 SHIPPING AND STORAGE MARKING.

"Shipping and Storage Marking requirements shall be: ____________ ____."

Rationale and Guidance: If the trainer is to be shipped or put into storage, then appropriate markings need to appear on the trainer.

Performance Parameters: MIL-T-81821, paragraph 3.3.3.23 (page 41) specifies the following:

> "All trainer equipment shall be marked for shipment and storage in accordance with MIL-STD-129."

However, before blanket reference is given, the engineer should review MIL-STD-129 and select the appropriate paragraphs or at least specify any acceptable exemptions.

Background and Sources: A source is identified in the discussion above.

Lessons Learned:

3.3.3.8 OTHER MARKINGS.

Rationale and Guidance: Subparagraphs 3.3.3.1 to 3.3.3.7 of the Prime Development Specification provide an opportunity to specify

marking requirements which are typical. However, other markings may be required; e.g.,

- Center of Balance Marking(s).
- Electric Motor Marking(s).
- Hoisting Instruction Markings.
- Marking of Fluid/Gaseous Transmission Lines.
- Marking of Identification Plates for Sectionalized Components.
- Power Switch Warning Plate Markings.
- Fluid Tank or Reservoir Markings.

Each of these is discussed below:

<u>Performance Parameters</u>:

<u>Center of Balance Markings</u>: MIL-T-81821, paragraph 3.3.3.8 (page 39) offers the following:

> "A vertical red arrow, approximately 2 by 6 inches, shall be stenciled on both longer sides of the trainer frame and outer cover, near the bottom edge, to indicate the point of balance of the trainer for forklifting. At the top of the arrrow, in red letters not less than 1 inch high, shall appear the legend CENTER OF BALANCE. If space is not available on the trainer frame for the 2-by-6-inch arrow, a red triangle or dot will be sufficient."

<u>Electric Motor Markings</u>: MIL-T-81821, paragraph 3.3.3.11 specifies the following:

> "All trainer peculiar unidirectional electric motors shall be marked to indicate the direction of rotation."

<u>Hoisting Instruction Markings</u>: MIL-T-81821, paragraph 3.3.3.19 (page 41) specifies:

> "Hoisting instructions for lifting a heavy trainer shall be stenciled on the cover, including lifting points, need for spreader bar, and area for forklifting. A heavy trainer shall be defined as having a weight exceeding the

one-man lift values of Table X in Paragraph 5.9.11.3.2 of MIL-STD-1472."

Marking of Fluid/Gaseous Transmission Lines: MIL-T-81821, paragraph 3.3.3.12 (page 40) suggests the following wording:

"All fluid/gaseous transmission lines and tubing shall be marked in accordance with MIL-STD-1247 with standard decals to indicate direction of flow, and shall bear the appropriate color code tape."

Marking of Identification Plates for Sectionalized Components: MIL-T-81821, paragraph 3.3.3.14 (page 40) specifies:

"Where the manufacturer's identification plate has been removed due to the sectionalization requirements, the plate shall be attached to that portion of the item that is mounted on the trainer, if possible. Otherwise, the identification plate shall be attached to the component mounting plate."

Power Switch Warning Plate Markings: MIL-T-81821, paragraph 3.3.3.15 specifies the following:

"A warning plate indicating 'WARNING--PLACE MASTER KEYED LOCK SWITCH IN OFF POSITION BEFORE CONNECTING OR DISCONNECTING EXTERNAL POWER' shall be attached to the plug end of each trainer power cable. Another warning plate with same legend shall be placed near the master keyed lock switch."

NOTE: If a master keyed lock switch is not used, then the above wording can be used with substitution of "Power Control" for "Master Keyed Lock Switch."

Fluid Tank or Reservoir Markings: MIL-T-81821, paragraph 3.3.3.16 suggests the following:

"The liquid capacity contents, and the words 'MUST BE DRAINED PRIOR TO SHIPMENT' shall be stenciled on any trainer fluid storage tank or reservoir."

NOTE: Emergency Power Switch marking can be presented either in this subparagraph or within some subparagraph of 3.3.6.5 of this specification. For convenience, the following wording is offered (from ASD Exhibit ENET 75-2D, 10 March 1978, page 22):

"All emergency off switches shall consist of red push buttons not less than 1.0 inch in diameter, recessed in black (FED-STD-595, Color 17038) and orange-yellow (FED-STD-595, Color 13538) diagonally striped panels, two inches or larger on a side. The width ratio of orange-yellow to black shall be three to one. The black stripe shall be in one of three widths: 1/16, 1/8, or 1/4-inch. The switch button shall not be integrally illuminated. Alternative lighting designs may be used that meet the requirement that the brightness contrast is sufficient to make the control identifiable under all projected illumination conditions. The control characteristics shall fall in the area labeled 'clear seeing' of sub note 3(1) DN2B2, DH 1-3. The nomenclature 'EMERGENCY OFF' shall be placed on each panel, consistent with the remainder of the panel nomenclature."

Background and Sources: Sources are identified in the discussion above.

Lessons Learned:

3.3.4 WORKMANSHIP.

"The trainer shall meet the workmanship requirements specified below: ______________________________."

Rationale and Guidance: A list of specific requirements is offered below, in the Performance Parameters section of this subparagraph. However it should be pointed out that other subparagraphs of the Prime Development Specification discuss or present workmanship requirements. Thus, the engineer should be careful not to duplicate such requirements within this subparagraph.

Performance Parameters: MIL-T-23991E, paragraph 3.15 (page 55) specifies "Workmanship shall be in accordance with Requirement 9 of MIL-STD-454."

Other areas to consider are:

- Welding; e.g., "All welding shall be accomplished in accordance with MIL-W-8604 and MIL-W-8611, as applicable."

- Hardware Installation; e.g., "The installation of hardware parts, such as hinges, catches, handles, or knobs shall be accomplished in such a manner as to avoid damaging the hardware or the mounting surface."

- Threaded Parts; e.g., "Screws, nuts, and bolts shall show no evidence of cross threading, mutilation, or detrimental or hazardous burrs.

- Wiring; many of these may have been presented in subparagraph 3.3.1.6.9.1 of the Prime Development Specification, but are included here for completeness (and to allow the engineer some flexibility in completing the text for this subparagraph):

  (1) Wire dress or cabling of wires shall not interfere with mechanical operation which could lead to subsequent damage of the wire or cable.

  (2) Wires and cables subject to flexing shall be protected to prevent abrasion.

  (3) There shall be no evidence of burns, abrasions or punch marks in the insulation that could cause short circuits or leakage.

  (4) Wires in continuous run between two terminals shall not be spliced during the assembly of the equipment, except where a strand conductor is spliced to a solid conductor and the two are supported at the splice.

  (5) The clearance between wires or cables and heat generating parts shall be such as to avoid deterioration of the wires on cables from the heat dissipated by these parts under the specified service conditions of the equipment.

  (6) Shielding on wires and cables shall be secured in a manner that will prevent it from contacting or shorting exposed current-carrying parts. The ends of the shielding or braid shall be secured against fraying.

- Screw Assemblies; e.g., "Assembly screws and bolts shall be torqued to the proper design values, without overtightening, based on their dimensions, material, and type of application, and shall be of a single thread type for each size used."

- Plug-in Modules; e.g., "Mating male and female plug-in modules shall be provided with positive keying safety arrangement to preclude insertion of a module into the wrong receptacle."

Background and Sources: Sources are identified in the discussion above.

Lessons Learned:

3.3.5 INTERCHANGEABILITY.

"The interchangeability requirements shall be as follows: ________
____.

Rationale and Guidance: A review of past specifications and military standards suggests three types of interchangeability should be considered in this subparagraph. The three types are: Physical Interchangeability, Structural Interchangeability, and Functional Interchangeability. Each of these is discussed below.

Performance Parameters: MIL-T-23991E, paragraph 3.2.1.1 suggests that interchangeability shall be in accordance with Requirement 7 of MIL-STD-454; ASD Exhibit ENET 75-2D, 10 March 1978, paragraph 3.3.5, suggests Requirement 7 of MIL STD-454 and MIL-STD-100 apply; while MIL-T-81821, paragraph 3.3.5 suggests that the requirements of MIL-I-8500 apply. However, Specification No. 16PS028A, paragraphs 3.3.5.1, 3.3.5.2, and 3.3.5.3, respectively offer the following:

> "Physical Interchangeability. Parts shall require only the removal of attaching means (bolts, nuts, screws, pins, etc.) in order to make replacement. Parts shall be capable of being replaced, one by the other, without harm, misalignment, or injury to adjoining parts or structure. Fabricating operations such as cutting, filing, drilling, reaming, hammering, bending, prying, or forcing shall not be required.
>
> Structural Interchangeability. When used interchangeably, the parts must not reduce the structural strength below the required value.
>
> Functional Interchangeability. When used interchangeably, the parts must fulfill the same functional purpose and design value, and not require circuit alignment and adjustment procedures beyond organizational level maintenance capabilities."

Furthermore ASD Exhibit ENET 75-2D, 10 March 1978 (page 12) suggests the following wording:

"Where components conforming to the part selection requirements specified herein are available in assorted dimensions and tolerance, provisions shall be made to accommodate the larger sizes as maintenance action replacements. Similarly, where stock listed items such as transistors, resistors, and capacitors of the same nominal performance characteristics with differing tolerance are available, the circuit design shall be designed to accommodate the widest tolerance for purpose of full maintenance."

Background and Sources: Sources are identified in the discussion above.

Lessons Learned:

3.3.6 SAFETY, GENERAL.

b. "The Military Standards referenced above shall apply except as stated below: ____."

Rationale and Guidance: Item a of subparagraph 3.3.6 of the Prime Development Specification provides blanket reference to the following Military Standards: Requirement 1 of MIL-STD-454, MIL-STD-1472 and MIL-STD-882. These references were specified in paragraph 3.3.6 of MIL-T-23991E. Item b allows the engineer to specify any exceptions to these blanket references; e.g., MIL-T-23991E specifies that an exemption should be granted for the "edge rounding requirement" of MIL-STD-1472. Other exemptions should be entered as identified by the engineer, after reviewing the specified or referenced standards.

In addition, it should be pointed out that ASD Exhibit ENET 75-2D, 10 March 1978, does not reference MIL-STD-882, but instead, in paragraph 3.3.6.7 states the following:

"The safety design of the training device shall be derived through the safety analysis and safety design reviews of the safety program required in the contract."

If this wording is preferred, then the last sentence in item a should be deleted and the above sentence added.

Performance Parameters: Review the Military Standards referenced in item a and enter any exemptions in item b.

Background and Sources: Sources are MIL-STD-882, Requirement 1 of MIL-STD-454, and MIL-STD-1472.

Lessons Learned:

3.3.6.1 HAZARDOUS MATERIAL.

NOTE: The provided wording was adopted from ASD Exhibit ENET 75-2D, 10 March 1978, paragraph 3.3.6.1 (page 12).

3.3.6.2 FIRE DETECTION.

"The fire detection requirements shall be as follows: ____________ ____."

Rationale and Guidance: There are two approaches that can be taken concerning fire detection. First, the maintenance trainer itself can contain detectors; i.e, the detectors can be built-in. The second approach is to rely on any fire detection system that the facility might have. This latter approach will not protect the equipment or facility as well as a built-in detection system; i.e., early detection is achieved by having the built-in system. In making the decision of which approach to use the engineer should consider the following factors:

- The detection system of the facility (if the facility has been identified).

- The complexity and nature of the equipment (e.g., if the trainer is likely to burn quickly, then a built-in detection system should be used - this increases the likelihood of minimizing damage and injury).

If it is decided to rely on the facility detection system this subparagraph can be deleted.

Performance Parameters: The following assumes the fire detection system is to be built-in. The following wording is adapted from ASD Exhibit ENET 75-2D, 10 March 1978, paragraph 3.3.6.2 (page 12):

> "The design shall include a complete fire, smoke detection, and alarm system which operates from facility power. Detectors shall be located in all appropriate contactor-furnished equipment, such as computer cabinets, student station(s), and instructor station(s). If the maintenance trainer requires the student to be in an enclosure (e.g., an enclosed simulated cockpit), then a

heat sensor wire shall be installed in the interconnecting cable(s). Means shall be provided to rapidly locate any fire or smoke which is detected. The detection and alarm cables shall be separated from electrical power cables. Detectors shall be installed in accordance with NFPA Standard 72E. The guidance of DN 5D2 of AFSC DH 1-6 shall apply."

Background and Sources: Primary source is ASD Exhibit ENET 75-2D, 10 March 1978, paragraph 3.3.6.2.

Lessons Learned:

3.3.6.2.1 FIRE ALARM.

"The fire alarm requirements shall be as follows: ____."

Rationale and Guidance: This subparagraph should only be completed if subparagraph 3.3.6.2 was completed; i.e., this subparagraph does not apply if the detection system is not built-in.

Performance Parameters: The following wording is an adaptation of paragraph 3.3.6.2.1 of ASD Exhibit ENET 75-2D, 10 March 1978:

"There shall be a system to alert all personnel throughout the training device complex that a fire or smoke detection has occurred. The specific aural or visual alarm means and locations to be provided shall be determined through safety analysis, and subject to approval by the procuring activity at the mockup/PDR. Care shall be exercised to insure that the specific means provided do not present confusing information when compared with stimuli from other alerting devices such as the facility fire alarm, or the alarms simulated in the cockpit maintenance trainer such as for a system malfunction."

Background and Sources: See ASD Exhibit ENET 75-2D, 10 March 1978, paragraph 3.3.6.2.1.

Lessons Learned:

3.3.6.2.2 FACILITY FIRE CONTROL INTERFACE.

"Facility fire control interface requirements shall be as follows: ____."

Rationale and Guidance: This subparagraph should not be completed if any of the following three circumstances prevail:

- Subparagraphs 3.3.6.2 and 3.3.6.2.1 were not completed (i.e., a built-in protection system is not a requirement).
- If the maintenance trainer is mobile and facility fire control interface is impossible or impractical.
- If there is no facility fire control system.

Performance Parameters: The following wording originates from ASD Exhibit ENET 75-2D, 10 March 1978, paragraph 3.3.6.2.2 (page 13):

"Interconnections with the facility fire control system shall be provided. Simulator smoke detection signals shall be provided to the facility fire control panel to provide a signal to activate the facility fire warning system in the appropriate facility fire zone where the simulator equipment is located. The simulator emergency power off shall be capable of being activated by a signal from the facility fire control panel originating from activation of a facility fire/smoke detector or sprinkler system."

Background and Sources: A source is referenced in the above discussion.

Lessons Learned: It should be noted that activation of a water sprinkler system may cause damage to the maintenance trainer. The purpose of the activation of the sprinkler is not to "save" the maintenance trainer but to save the facility.

3.3.6.3 OVERHEAT SENSING.

"The overheat sensing requirements are as follows: ____."

Rationale and Guidance: This subparagraph should be completed only if a cooling system is a requirement.

Performance Parameters: The following wording is a combination of the wording originating from MIL-T-81821, paragraph 3.3.6.2 and ASD Exhibit ENET, 75-2D, 10 March 1978, paragraph 3.3.6.3:

"Each major component, such as the instructor station, student station, and the computer cabinet, which is provided with a cooling system shall automatically

deactivate power to the affected component in the event of a cooling system failure. Each component shall have its own warning system so that the specific component on which the failure has occurred can be identified."

Background and Sources: Sources are referenced in the discussion above.

Lessons Learned: Warning lights are typically used for this purpose.

3.3.6.4 FIRE STOP SEALING.

Rationale and Guidance: Fire seals are typically used when the trainer is picking up power (either electrical or hydraulic) from the facility.

If a false floor is going to be used for the computer equipment, then provisions must be made for controlling fire; however, this is usually not the responsibility of the contractor.

Performance Parameters: Consider the following wording, originating from ASD Exhibit ENET 75-2D, 10 March 1978 (page 13):

"Means shall be provided to seal facility-provided fire stops whenever training device cable runs are installed through the fire stop."

Background and Sources: Source is identified in discussion above.

Lessons Learned:

3.3.6.5 EMERGENCY POWER-OFF.

a. "The emergency power-off requirement shall be as follows: ____ ____."

Rationale and Guidance: Emergency power-off should occur automatically in the following situations:

- When fire and smoke have been detected.
- When fast-acting mechanical parts have trapped limbs of the user (if such an event can be "sensed" on the training equipment).

In addition, emergency power-off should be activated by personnel observing a personal injury via an emergency power-off switch. The switch is to be described in item b of this subparagraph.

Both the automatic and manual activated power-off control should be viewed as a personnel safety feature and not as an equipment salvation feature (i.e., emergency power-off is activated to save personnel and not equipment). Note an emergency power-off should

not require an orderly shutdown (e.g., a shutdown that saves memory or core registers), the prime objective is safety of personnel.

Performance Parameters: When establishing the performance criteria, consideration should be given to the following:

- Location of emergency power-off switches.

- When automatic activation is required (e.g., detection of fire or smoke).

- What occurs during activation (e.g., should utility power be turned off, should emergency lighting be turned on).

The following wording has been adapted from ASD Exhibit ENET 75-2D, 10 March 1978, paragraph 3.3.6.5:

> "Emergency power off control shall be provided at multiple locations throughout the training complex and shall be fail-safe. The number and location of these controls shall be subject to procuring activity approval at the mockup/PDR. Emergency power off shall also occur automatically when the fire/smoke detection system is activated. When emergency power off is initiated, all power to the training equipment, including utility power, shall be automatically removed. If the trainer involves an enclosure in which the student might be confined or located then upon activation of the emergency power off control the enclosure shall return an egress position and any egress ramps or stairways shall also return to an egress position. In addition, emergency lighting shall be activated on all enclosed areas as well as all possible escape routes. Furthermore, provisions shall be made to close all ventilation/air conditioning dampers automatically. Alternate escape provisions shall be provided and be subject to approval by the procuring activity."

Background and Sources: A source reference is given in the discussion above.

Lessons Learned:

b. "The emergency power-off switch shall: ______________________ ____."

Rationale and Guidance: As an alternative the information requested here can be provided in subparagraph 3.3.3.8. However for maximum flexibility the same phrasing is offered here.

Performance Parameters: Consider the following wording from ASD Exhibit ENET 75-2D, 10 March 1978 (page 22):

> "All emergency off switches shall consist of red push buttons not less than 1.0 inch in diameter, recessed in black (FED-STD-595, Color 17038) and orange-yellow (FED-STD-595, Color 13538) diagonally striped panels, two inches or larger on a side. The width ratio of orange-yellow to black shall be three to one. The black stripe shall be in one of three widths: 1/16, 1/8, or 1/4-inch. The switch button shall not be integrally illuminated. Alternative lighting designs may be used that meet the requirement that the brightness contrast is sufficient to make the control identifiable under all projected illumination conditions. The control characteristics shall fall in the area labeled 'clear seeing' of sub note 3(1) DN2B2, DH 1-3. The nomenclature 'EMERGENCY OFF' shall be placed on each panel, consistent with the remainder of the panel nomenclature."

Background and Sources: Reference is offered in the above discussion.

Lessons Learned:

3.3.6.6 OTHER SAFETY REQUIREMENTS.

Rationale and Guidance: Subparagraphs 3.3.6.1 through 3.3.6.5 specify specific safety requirements. This subparagraph is reserved for trainer-peculiar items, such as an emergency intercommunication system and an emergency lighting system.

Performance Parameters:

- Emergency Communication System. Such systems are typically not used on a maintenance trainer. However, if the trainer is designed such that enclosures are required or that part of the trainer is in a different room then an emergency communication system might be required. When identifying the system indicate:

  - Locations of intercommunciation devices.
  - Activation procedures (when activated).
  - Frequency range.
  - Signal strength, etc.

- Emergency Lighting System. Typically emergency lighting is used if the trainer is designed as an enclosure. Consider the following wording adapted from ASD Exhibit ENET, 75-2D, 10 March 1978, paragraph 3.3.1.7.2:

  > "When required by facility lighting, low intensity guarded lights shall be provided to illuminate the walkway, stairways, ramps, and enclosures. Where necessary, enclosure interior emergency lighting shall be provided and be activated automatically upon loss of facility power. When used, emergency lighting batteries shall be:
  >
  > - Rechargeable.
  > - Leakproof, spill proof.
  > - Low maintenance.
  > - Long life."

Background and Sources: Sources are identified in the above discussion.

Lessons Learned: Often the engineer cannot perceive all possible hazards and their control. MIL-T-23991E, paragraph 3.2.1.2.2 (page 27) suggests the following general statement:

> "In the event that one or more design features of this specification ... constitute a hazard to personnel using or maintaining the training equipment, notification of this condition shall be made to the procuring activity for direction. This notification shall include recommendations for appropriate revisions to remove the hazard."

The above wording would be appropriate to use in completing this subparagraph.

3.3.6.7 ACOUSTIC NOISE.

3.3.6.7.1 HAZARDOUS NOISE.

a. "The maximum dBA exposure allowable shall be: ______________ ____."

Rationale and Guidance: Item a sets a sound level and exposure time criteria. Typically this has been set using a table, e.g., "Threshold Limit Values for Non-impulsive Noise" (American Conference of Governmental Industrial Hygienists). The formula offered in item a is an approximation of these tables. A problem emerges, in using this formula, which should be carefully thought out. It provides a daily exposure at a specific dBA. Typically the contractor or vendor will determine the dBA of the maintenance trainer and then provide the duration time. However, this time may not be practical in terms of the training; e.g., a 15 minute exposure of 115 dBA may not be a sufficient time to accomplish the training. If time and noise level are a problem, then this subparagraph should specify the time of the training at some predictive dBA or range of dBAs; e.g., "The trainer shall be designed to permit a ___ hour exposure at a maximum of ___ dBA." To complete the blanks in the above sentence the engineer must use a table directly.

Secondly, the provided formula does not allow the calculation of an exposure time if there are two or more noise levels (simultaneously) from two or more sources (NOTE: a rough approximation can be obtained by adding the two dBAs as logs and by substituting this combined value in the formula for L). However, a more accurate approximation can be obtained using a standard table and adding (directly and not as logs) the obtained values.

Item b is provided only to assure that a maximum recommended dBA is not exceeded. The maximum recommended dBA is given in the next paragraph.

Performance Parameters: Currently the maximum recommended value is 115 dBA.

Background and Sources: 115 dBA maximum originates from OSHA literature and AFR 161-35. 115 dBA can be exceeded providing ear protection is provided, but ear protection may not be appropriate if the maintenance trainer is used as a demonstration device.

Lessons Learned: It seems appropriate to suggest that training cannot be conducted at the maximum recommended dBA. Trainers should be designed to allow speech to be heard (see paragraph 3.3.6.7.2 of the specification).

3.3.6.7.2 SPEECH INTERFERENCE LEVEL.

NOTE: Wording originates from ASD Exhibit ENET 75-2D, 10 March 1978, paragraph 3.3.8.2 (page 15).

This subparagraph guarantees that students will be able to hear the instructor during a demonstration, while the maintenance trainer is operating.

3.3.6.8 SAFETY DESIGN.

"The safety design requirements shall be as follows: ____________ ____."

Rationale and Guidance: This subparagraph provides an opportunity for the engineer to specify any special design requirements.

Performance Parameters: ASD Exhibit ENET 75-2D, 10 March 1978, paragraph 3.3.6.7 (page 14) suggests the following design notes (DN) of AFSC D 1-6 should apply:

- DN 2C2, Man-Machine Safety Design Requirement.
- DN 2E1, 2, and 3, Introduction, Procedures, and Selection of Safety Analyses.
- DN 2E4, Resolution of Safety Hazards.
- DN 4A2, Material Handling Equipment.
- DN 5D2, Fire Detection.
- DN 6A1-7, Environmental Parameters of Man.
- DN 4E1-2, Electrical/Electronic Equipment.
- DN 4C1-3, Hydraulic Equipment.

Background and Sources: Sources are identified in the above discussion.

Lessons Learned:

3.3.7 HUMAN PERFORMANCE/HUMAN ENGINEERING.

"In order to achieve optimum performance of the instructor, student, and maintenance personnel, and to assure a high degree of

man-machine compatibility, the trainer shall: ________________
____."

Rationale and Guidance: It is essential that the trainer be designed considering human factor interactions. There are many military standards and specifications which deal with human engineering.

Performance Parameters: MIL-T-81821, paragraph 3.3.7 (page 42) suggests that the criteria of MIL-STD-1472 be applied. ASD Exhibit ENET 75-2D, 10 March 1978, paragraph 3.3.7 (page 14) suggests that paragraphs 5.10, 5.11, and 5.12 of MIL-STD-1472 not be applied. In addition, ASD Exhibit ENET 75-2D, also suggests that the requirements of MIL-H-46855 be applied. MIL-T-23991E, paragraph 3.2.1.6 (page 30) adds the following: "The Human Engineering Guide to Equipment Design shall be used in providing additional design guidance for work space, layout, consoles, controls, and displays."

The engineer should review the documents listed above and specify any exemptions.

Background and Sources: Sources are identified in the discussion above.

Lessons Learned:

3.4 DOCUMENTATION.

Rationale and Guidance: Documentation is an important aspect of maintenance trainer use, operation, and maintenance. All materials and documentation shall be in accordance with applicable Data Item Descriptions (DIDs).

Performance Parameters: Several documents should be specified. The list below is not meant to be comprehensive:

- Drawings: For example wiring diagrams, schematics, engineering drawings (see DID Item No. DI-E 6106).

- Maintenance Instructions: Instructions concerning service, adjustments, calibrations, and repair procedures; e.g., isolation procedures including fault trees or diagrams (see DID No. DI-M-6152).

- Operation Manuals: Manuals on how to set-up, initialize, and operate the trainer; the manual should contain a description of each of the instructional features (when and how to use). (See DID No. DI-M-6152.)

- Software Maintenance and Update: Manuals concerning how to alter software to create new malfunctions and how to update or change any data file or data blocks, particularly those associated with any mathematical model or instructional feature (e.g., altering automatic scoring criteria).

- Instructor Manual: Manual describing training and exercises or problems, how to select problems, etc. (see DID No. DI-A-6103).

- Technical Manuals: Technical manuals, printed or graphic material containing current information that affects the maintenance and operation of the maintenance trainer and any support test equipment.

- Illustrated Parts Breakdown: For each component (e.g., instructor station, student station, computer).

- Reports:

  (1) Maintenance Training Equipment Progress Report - Monthly Report (see DID No. DI-A-6134).

  (2) Maintenance Training Equipment Facility Report - (see DID No. DI-H-6155).

  (3) Maintenance Training Cost Report - reports historical cost data (see DID No. DI-F-6125).

  (4) Maintenance Training Equipment Material Requirement/Receipt Report - contains management information for monitoring receipt and progress (see DID No. DI-A-6103).

  (5) Maintenance Training Equipment Material Shortage Report - monthly (see DID No. DI-P-6164).

  (6) Maintenance Training Equipment Rejected/Nonoperable Parts Utilization Report - (see DID No. DI-L-6139).

  (7) Maintenance Training Equipment Engineering Changes Status Report - quarterly report (see DID No. DI-E-6118).

For other reports see pages 46 and 47 of MIL-T-81821.

- Software Documentation: For example, system diagrams, program flow charts, and actual software code (DID No. DI-H-3119 and 3120).

APPENDIX E

EXAMPLE: INSTRUCTIONAL FEATURE SCENARIO

SIMULATOR INSTRUCTIONAL FEATURE DESIGN GUIDE

Feature:

Demonstation Preparation

Definitions:

Demonstation Preparation (Demo Prep) is a simulator instruction feature that enables a simulator instructor to prepare a Demonstattion (Demo) for repeated use during subsequent periods of pilot training.

Purpose and Intended Use:

The purpose of the Demo Prep feature is to permit Demos to be prepared by recording a period of performance in the simulator, modifying that recording to enhance its instructional value, and adding an expository or instructional commentary. The skills required to prepare a Demo using this feature are those normally found among simulator instructors who are pilots, and no additional technical training or computer programming skills are required. Nevertheless, it is expected that only designated instructors will prepare Demos in order that control may be exercised over Demonstration content and format.

Recording a Demo in the simulator will normally be preceded by the development of a scenario for the Demo. A script of the planned instructional commentary will be prepared and, in addition, the scenario will identify the simulated conditions under which the maneuver(s) of interest will be flown, the number of repetitions of all or designated portions of the maneuver that are to be included in the completed Demo, where Pauses are to appear, and which segments are to be presented in Slow Time. The scenario also will identify the beginning of each Demo segment that is to be direcly accessible by the instructor. The script will be edited to assure that proper time relationships will be maintained between the content of the Demo and the related commentary.

Following development of the scenario, with its accompanying audio commentary, the Demo described in it will be developed by flying the simulated aircraft through the maneuver or series of maneuvers to be demonstrated while the flight is being recorded. This process may be

repeated until the instructor is satisfied that the maneuver has been flown to the required standards. While making the recording, the instructor (with the assistance of a second instructor located at the IOS) would make use of the simulat‹r's other instructional features such as Freeze, and Store/Reset Current Conditions, as often as necessary to obtain a "model" performance of the maneuver being flown. If the scenario requires that the Demo include more than a single repetition of the maneuver, as usually will be the case, the recording process will be repeated as many times as may be required.

Upon completing the recording of the maneuver, the instructor will "edit" it in accordance with the scenario by inserting Pauses when extended instructional commentary might be required or by "stretching" to Slow Time parts of the maneuver which occur too rapidly in real time for the pilot to be able to see important task interrelationships. He then would add Demo segment identifiers that will permit direct access to the beginning of individual segments when the Demo is employed in the instructional process.

Finally, using the script prepared for that purpose, the instructor will add the prepared instructional commentary to the recorded Demo. Recording the audio, which would normally be done while the newly prepared Demo is being replayed and monitored, will require careful attention--and possibly several practice trials--to synchronize the commentary with the instructional events being commented upon.

Because of limits upon humans' attention span and short-term recall abilities, the more effective Demos will tend to be relatively brief. The subject matter of Demos will consit of complex individual maneuvers or rapidly occurring series of maneuvers of which verbal descriptions alone might not provide enough information for pilots to learn rapidly to perform them. It is not expected that Demos will be prepared to illustrate mission segments in which individual maneuvers are separated by extended periods of relatively simple aircraft control tasks. For these reasons, most Demos, including those which contain Pauses and Slow Time segments, will be of less than five minutes duration. Demos of more than ten munutes would be counterproductive in most instances and should not be prepared.

Function Descriptions

ENABLE. Preparation of a Demonstration is a function that cannot be performed while instruction is in progress. To assure preservation of previously prepared Demonstrations, and to exercise administrative control over preparation of new ones, the Demo Prep feature cannot be enabled from the IOS.

SET UP SIMULATOR. Setting up the simulator for the task of preparing a Demo, except for the necessary enablement, is comparable to setting it up for an instructional activity. Thus, initial condition parameters which define the flight environment and the aircraft position and status must be selected and entered. After this has been done, the simulator may be flown just as during a period of simulator instruction, and the instructional activity control features of the simulator normally available during such training may be used in preparing the Demo.

RECORD MANEUVER. Upon terminating freeze status, the simulator performance will be recorded as flown. The instructor will fly the maneuvers that comprise the first (or next) portion of the Demo scenario.

REPLAY. After a portion of the Demo is recorded the instructor will use the replay function to determine if the recording is satisfactory. He may erase and rerecord (i.e., record over) maneuver records that he judges not to be satisfactory.

RECORDING COMPLETED. The recording and replay processes described above will be continued unitl the instructor has assembled the necessary examples of the maneuver that is the subject of the Demo being developed. The instructor making the Demo may record numerous satisfactory trials sequencially until he has the number of satisfactory trials and variations of trials his scenario requires. For each period of Demo recording he may reestablish the previously selected initial conditions, or a different set of conditions as may be required, to produce a Demo consistent with the scenario.

EDIT. When the instructor has completed recording all of the necessary segments of flight, he will edit the recording as described below to meet the Pause and Slow Time requirements of the scenario.

ADD PAUSE. The instructor will play back the recorded maneuver, and, at points during the playback indicated in the scenario, he will insert periods of Pause. During these periods, the Demo will continue to replay, but the simulated events will be in a suspended or "stop-action" status. Suspending these simulated events without stopping the Demo will permit the later recording of a more lengthy commentary explaining the event than would be possible without Pauses. A Pause may be of any length within the limits of playback time permitted for a Demo.

CHANGE TO SLOW TIME. Segments of the recorded maneuver may be "stretched" from real time to slow time so it will be easier for a pilot to see just what the performance being demonstrated consists of. This stretching will be done, in accordance with the previously

developed scenario, by replaying the portion of the maneuver to be stretched while the Change to Slow Time function is exercised. The length of the segment changed to Slow Time is limited only by the total time available for that Demo.

ADD SEGMENT IDENTIFICATION. After all Pauses have been entered and Slow Time conversions have been made, the instructor will replay the Demo (which will now be at its full length) and divide it into independently addressable segments by "flagging" the points at which each such segment is to begin. These "flags" will be located in accordance with scenario specifications and will generally be at the beginning and/or at the end of Pauses and Slow Time segments, and at the beginning of complete cycles of the maneuver being demonstrated.

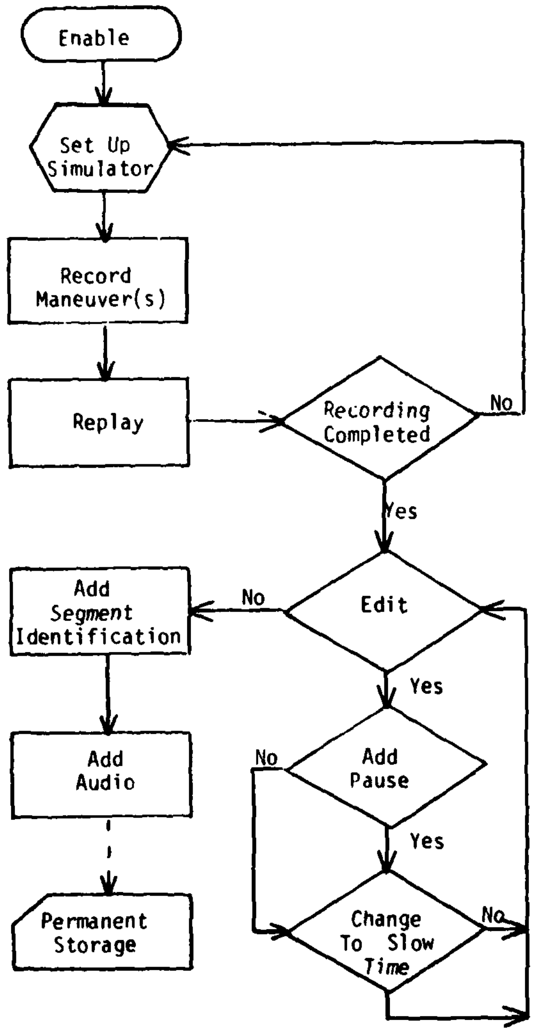
ADD AUDIO. The final task of the instructor preparing a Demo will be to add the instructional commentary. This will be done by reading the script prepared during development of the Demo Scenario onto a synchronized tape or other recording medium while the Demo is being replayed and monitored.

PERMANENT STORAGE. When the Demo has been prepared and reviewed by the instructor, and he is fully satisifed that it will provide the instruction intended (i.e., that no further editing or rerecording is required), it will be stored with other Demos for use during subsequent periods of instruction.

Concurrent Events:

While a Demo is being prepared, all simulator controls normally available during periods of instruction will retain their normal functions except those associated with the Record/Playback feature. These controls may be used to create and modify conditions and events that will be included in the recorded Demo. Thus, the instructor may employ the Store/Reset Current Conditions feature, or he may change visibility on the visual display or activate hostile weapons. He also may employ the Hardcopy and Remote Display instructional features and the performance measurement and data summary capabilities of the simulator to examine the maneuver he has just recorded in order to determine its adequacy for his instructional purposes.

Feature Diagram:



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MAINTENANCE TRAINING SIMULATOR DESIGN AND ACQUISITION.(U)
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INFORMATION

DEPARTMENT OF THE AIR FORCE
AIR FORCE HUMAN RESOURCES LABORATORY (AFSC)
BROOKS AIR FORCE BASE, TEXAS 78235

Errata

AD-A089149

16 JAN 1981

REPLY TO ATTN OF: TSR

SUBJECT: Removal of Export Control Statement

TO: Defense Technical Information Center
Attn: DTIC/DDA (Mrs Crumbacker)
Cameron Station
Alexandria VA 22314

1. Please remove the Export Control Statement which erroneously appears on the Notice Page of the reports listed [redacted]. This statement is intended for application to Statement B reports only.

2. Please direct any questions to AFHRL/TSR, AUTOVON 240-3877.

FOR THE COMMANDER

Wendell L Anderson

WENDELL L. ANDERSON, Lt Col, USAF
Chief, Technical Services Division

1 Atch
List of Reports

Cy to: AFHRL/TSE